THE
POPULAR SCIENCE
MONTHLY.

APRIL, 1901.

MALPIGHI, SWAMMERDAM AND LEEUWENHOEK.

By Professor WILLIAM A. LOCY,
NORTHWESTERN UNIVERSITY.

As Cuvier justly remarks, the seventeenth century was a fruitful one for science. It was then that the method of investigating nature by direct observation and experiment was reestablished. After the long period of intellectual decline, the mental life of mankind was to be lifted again to the level it had attained in the age of the highest development of Greek philosophy. The complete arrest of inquiry into the domain of nature and the adherence to tradition had lasted so long that the faculty of testing and experimeting seemed to be almost extinct. The unfriendliness of the ecclesiastics and other intellectual authorities to investigation, and the dire consequences to the individual of a movement towards intellectual freedom, served to repress the natural desire of the human intellect for a knowledge of itself and the universe. Any one who broke over the restraints went against every appeal to self-interest, and deserved much credit for independence and courage.

Nevertheless, in this untoward atmosphere the spirit of unbiased inquiry was awakened through the efforts of a few independent minds; among these select few, who, as pioneers in the revival of exact science, have an enduring interest for all educated people, we must remember Malpighi, Swammerdam and Leeuwenhoek. Although their work marks an epoch, they were not the only pioneers, nor the first ones; Vesalius, Galileo, Harvey and Descartes had started the reform movement in which our triumvirate so worthily labored.

One of these men—Malpighi—was an Italian, and the other two were Netherlands Dutchmen. Their great service "consisted chiefly in this, that they broke away from the thraldom of book-learning, and, relying alone upon their own eyes and their own judgment, won for man that which had been quite lost, the blessing of independent and unbiased observation." The importance of this step for its broad-reaching effects even upon the intellectual life of our own time is not easily overestimated. Much of the work of the present is built upon the foundations they laid.

There is a singularly unappreciative attitude towards scientific work, of the biological kind, done before 1850, and a widespread disposition to look upon the advances of the present time as peculiarly our own, based wholly upon 'modern' work and 'modern' methods. This sometimes takes the extreme form, in the rising generation of practical workers, of looking upon the scientific investigations of the past ten years as of necessarily better quality than those of any preceding period, because they are the most recent. But this is to do injustice to our predecessors, and it is wholesome to take a look into the past, to see some of the fine observational work done long ago, and to be compelled to recognize the continuity of biological development, both as regards work and ideas.

If it were Johannes Müller with whom we were to deal, a marvel could be shown, but the work of Malpighi, Swammerdam and Leeuwenhoek belongs to a period a century and a half before his time. For these men it is just to claim, in addition to the service indicated above, the possession of the true scientific spirit, the introduction of the microscope and of more exact methods into scientific investigation, and, through their work, the beginning of that better comprehension of the natural universe that we call modern science.

It is natural that working when they did, and independently as they did, their work overlapped in many ways. Malpighi is noteworthy for many discoveries in anatomical science, for his monograph on the anatomy of the silkworm, for observations on the minute structure of plants and on the development of the chick in the hen's egg. Together with Grew, he is regarded as the founder of plant histology. Swammerdam did excellent and accurate work on the anatomy and metamorphosis of insects and the internal structure of mollusks, frogs and other animals. Leeuwenhoek is distinguished for much general microscopic work; he discovered various microscopic animalcula; he established by direct observation a connection between arteries and veins, and examined microscopically minerals, plants and animals. To him more than to the others the general title of 'microscopist' might be applied.

Let us, by taking them individually, look a little more closely at the lives and labors of these men.

MARCELLUS MALPIGHI. 1628-1694.

There are several portraits of Malpighi extant. These, together with the account of his personal appearance given by Atti,* enable us to tell what manner of man he was. The portrait given here is the

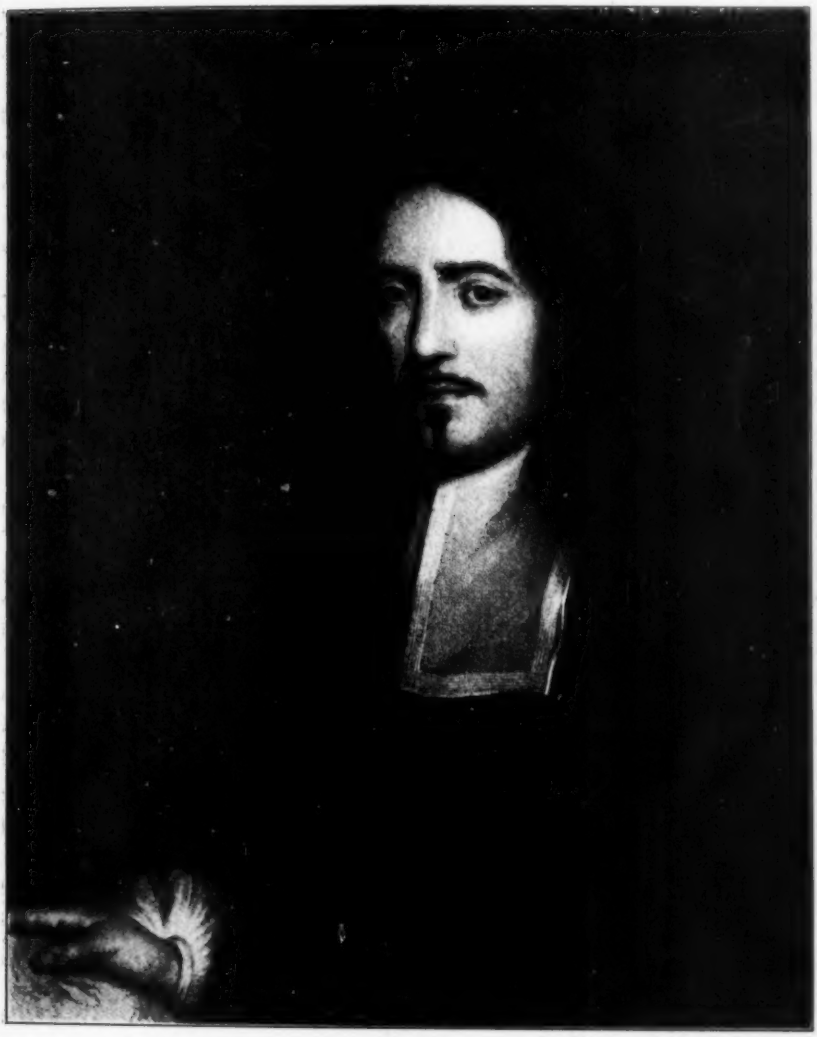


FIG. 1. MARCELLUS MALPIGHI.

one painted by Tabor, and presented by Malpighi to the Royal Society of London. As Pettigrew says, 'it shows a countenance highly intellectual, and as a work of art is of no mean importance.' Some of the other

* Atti. 'Notizie Edite ed Inedite Della Vita e Delle Opére Di Marcelli Malpighi De Lorenzo Bellini.' Bologna, 1847; 4°; 525 pp.

portraits are less attractive, and give evidence of imperfect health in the lines and wrinkles of his face. According to Atti, he was of medium stature, with a brown skin, delicate complexion, a serious countenance and melancholy look.

Accounts of his life show that he was modest, quiet and of a pacific disposition, notwithstanding the fact that he lived in an atmosphere of acrimonious criticism, of jealousy and controversy. Under all this he suffered acutely, and his removal from Bologna to Messina was partly to escape the harshness of his critics. Some of his best qualities showed under these persecutions; he was dignified under attack and moderate in reply. In his posthumous works his replies to his critics are free from bitterness and written in a spirit of great moderation. This picture from Ray's correspondence shows the same control of his spirit. Under the date of April, 1684, Dr. Tancred Robinson writes: "Just as I left Bononia I had a lamentable spectacle of Malpighi's house all in flames, occasioned by the negligence of his old wife. All his pictures, furniture, books and manuscripts were burnt. I saw him in the very heat of the calamity, and methought I never beheld so much Christian patience and philosophy in any man before; for he comforted his wife and condoled nothing but the loss of his papers."

Malpighi was born at Crevalcuore, near Bologna, in 1694. His parents were farmers, or landed peasants; enjoying a certain independence in financial matters, they designed to give Marcellus, their eldest child, the advantages of masters and the schools. He began a life of study, and showed a taste for belles-lettres and for philosophy, which he studied under Natali.

Through the death of both parents, in 1649, Malpighi found himself, at the age of twenty-one, an orphan, and, as the eldest of eight children, domestic affairs devolved upon him. He had as yet made no choice of profession, but, through the advice of Natali, he resolved, in 1651, to study medicine, and, in 1653, at the age of twenty-five, he received from the University of Bologna the degree of M. D.

In the course of a few years he married the sister of Massari, one of his teachers in anatomy, and became a candidate for a position in the University of Bologna. This he did not immediately receive, but about 1656 he was appointed to a post in the University, and began his career as teacher and investigator. He must have shown aptitude for this work, for soon he was called to the University of Pisa, where, fortunately for his development, he became associated with Borelli, who was older and assisted him in many ways. They united in some work, and together they discovered the spiral character of the heart muscles. But the climate of Pisa did not agree with him, and after three years he returned, in 1659, to teach in the University of Bologna, and applied himself assiduously to anatomy.

Here his fame was in the ascendant, notwithstanding the machinations of his enemies and detractors, led by Sbaraglia. He was soon (1662) called to Messina to follow the famous Castelli. After a residence there of four years he again returned to Bologna. He retired to a villa near the city, and devoted himself to anatomical studies.

Malpighi's talents were appreciated even at home. The University of Bologna honored him in 1686 with a Latin eulogium, the city erected a monument to his memory, and after his death, in the city of Rome, his body was brought to Bologna and interred with great pomp and ceremony. He also received recognition from abroad, but that is less remarkable. In 1668 he was elected an honorary member of the Royal Society of London. He was very sensible of this honor; he kept in communication with the society; he presented them with his portrait, and deposited in their archives the original drawings illustrating the development of the chick.

In 1691 he was taken to Rome by the newly elected Pope, Innocent XII, as his personal physician, but under these new conditions he was not destined to live many years. He died there, in 1694, of apoplexy. His wife, of whom it appears that he was very fond, had died a short time previously. Among his posthumous works is a sort of personal psychology written down to the year 1691, in which he shows the growth of his mind and the way in which he came to take up the different subjects of investigation.

In reference to his discoveries and the position he occupies in the history of natural science, it should be observed that he deserves the title of an 'original as well as a very profound observer.' While the ideas of anatomy were still vague 'he applied himself with ardor and sagacity to the study of the fine structure of the different parts of the body'; he extended his studies to the structure of plants and different animals, and also to development. Entering as he did, a new and unexplored territory, he, of course, made many discoveries, but no man of mean talents could have done his work. He used every method at his command for investigating the structure of tissues and animal forms—macerating, boiling, injections of ink and colored fluids, and also applied the microscope to the discovery of tissues.

During forty years of his life he was always busy with research. Many of his discoveries had practical bearing on the advance of anatomy and physiology as related to medicine. In 1661 he demonstrated the structure of the lungs. Previously these organs had been regarded as a sort of homogeneous parenchyma. He showed the presence of air-cells, and had a tolerably correct idea of how the air and blood are brought together in the lungs, the two never actually in contact, but always separated by a membrane. These discoveries were first made on the frog, and applied by analogy to the interpretation of the lungs

of the human body. He was the first to insist on analogies of structure between organs throughout the animal kingdom, and to make extensive practical use of the idea, that discoveries on simpler animals can be utilized in interpreting the similar structures in the higher ones.

It is very interesting to note that in connection with this work, he actually observed the passage of blood through the capillaries of the transparent lungs of the frog, and also in the mesentery. Although this antedates the similar observations of Leeuwenhoek, nevertheless the work of Leeuwenhoek was much more complete, and he is usually recognized in physiology as the discoverer of the capillary connection between arteries and veins. At this same period Malpighi also observed the blood corpuscles.

Soon after he demonstrated the mucous layer, or pigmentary layer of the skin, intermediate between the true and the scarf skin. He had separated this layer by boiling and maceration, and described it as a reticulated membrane. Even its existence was for a long time controverted, but it remains in modern anatomy under the title of the malpighian layer.

His observations on glands were extensive, and while it must be confessed that many of his conclusions in reference to glandular structure were erroneous, he left his name connected with the malpighian corpuscles of the kidney and the spleen. He was also the first to indicate the presence of papillæ on the tongue. This is a respectable list of discoveries, but much more stands to his credit. Those which follow have a bearing on comparative anatomy, zoology and botany.

Monograph on the Structure and Metamorphosis of the Silkworm. Malpighi's work on the structure of the silkworm takes rank among the most famous monographs on the anatomy of a single animal. Much skill was required to give to the world this picture of minute structure. The marvels of organic architecture were being made known in the human body and the higher animals, but 'no insect—hardly, indeed, any animal—had then been carefully described, and all the methods of work had to be discovered.' The delicacy, beauty and intricacy of the organic systems in this group of animals were well calculated to arouse wonder and admiration. He worked with such enthusiasm in this new territory as to throw himself into a fever and to set up an inflammation in the eyes. "Nevertheless," says Malpighi, "in performing these researches so many marvels of nature were spread before my eyes that I experienced an internal pleasure that my pen could not describe." In the words of Miall:

"We must recall the complete ignorance of insect-anatomy which then prevailed, and remember that now for the first time the dorsal vessel, the tracheal system, the tubular appendages of the stomach, the reproductive organs, and the structural changes which accom-

pany transformation were observed, to give any adequate credit to the writer of this masterly study. Treading a new path, he walks steadily forward, trusting to his own sure eyes and cautious judgment. The descriptions are brief and simple, the figures clear, but not rich in detail. There would now be much to add to Malpighi's account, but hardly anything to correct. The only positive mistakes which meet the eye relate to the number of spiracles and nervous ganglia—mistakes promptly corrected by Swammerdam."

He showed that the method of breathing was neither by lungs nor gills, but through a system of air-tubes, communicating with the exterior through button-hole shaped openings, and, internally, by an infini-

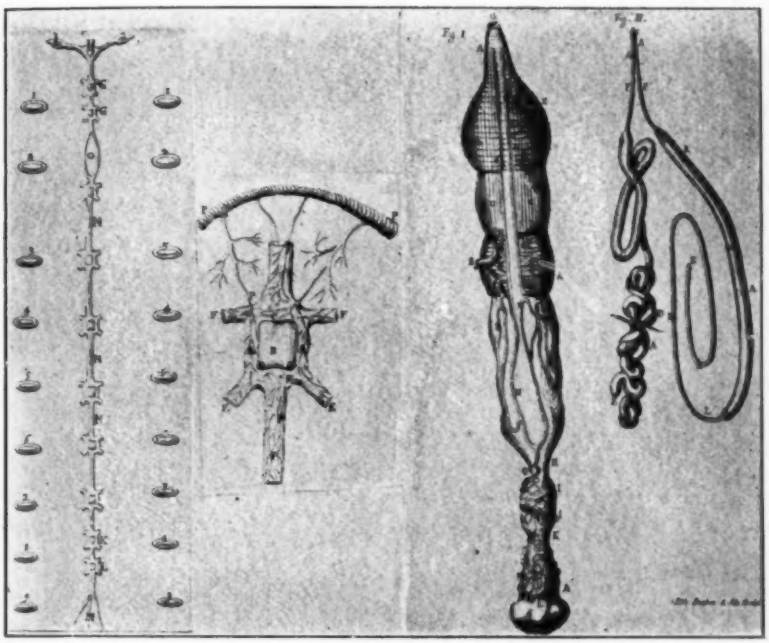


FIG. 2. FROM MALPIGHI'S ANATOMY OF THE SILKWORM.

tude of branches reaching to the minutest parts of the body. Malpighi showed an instinct for comparison; instead of confining his researches to the species in hand, he extended his observations to other insects, and he gives sketches of the breathing tubes, held open by their spiral thread, taken from several species.

The nervous system he found to be a central white cord with swellings in each ring of the body, from which nerves are given off to all organs and tissue. The cord which is, of course, the central nervous system, he found located mainly on the ventral surface of the body, but extending by a sort of collar of nervous matter around the œsophagus and, on the dorsal surface, appearing as a more complex mass, or brain,

from which nerves are given off to the eyes and other sense organs of the head. As illustrations from the monograph we have, in Fig. 2, reduced sketches of the drawings of the nervous system and the food canal in the adult silkworm. The sketch at the left hand illustrates the central nerve cord, and the small one near the center shows one ganglion enlarged, and part of the breathing tubes connected with it. The original drawing is on a much larger scale, and reducing it takes away some of its coarseness. All of his drawings lack the finish and detail of Swammerdam's work.

He showed also the food canal and the tubules connected with the intestine, which retain his name in the insect anatomy of to-day, under the designation of malpighian tubules. The silk-forming apparatus was also figured and described. These structures are represented, as Malpighi drew them, on the right of Fig. 2.

This monograph, which was originally published in Latin in 1669, has been several times republished. The best edition is that in French, dating from Montpellier, in 1878, and which is preceded by an account of the life and labors of Malpighi.

Anatomy of Plants. Malpighi's anatomy of plants constitutes one of his best as well as one of his most extensive works. In the folio edition of his works, 1675-79, the 'Anatome Plantarum' occupies not less than 152 pages and is illustrated by ninety-three plates of figures. It comprises the structure of bark, stem, roots, seeds, process of germination, treatise on galls, etc., etc.

The microscopic structure of plants is amply illustrated, and he anticipated to a certain degree the ideas on the cellular structure of plants. Burnett says of this work: "His observations appear to have been very accurate, and not only did he maintain the cellular structure of plants, but also declared that it was composed of separate cells, which he designated 'utricles.'" Thus did he foreshadow the cell-theory of plants, as developed by Schleiden in the nineteenth century. When it came to interpretations of his observations, he made several errors. Applying his often-asserted principle of analogies, he concluded that the vessels of plants are organs of respiration and of circulation from a certain resemblance that they bear to the breathing tubes of insects. But his observational work on structure is good, and if he had accomplished nothing more than this work on plants he would have a place in the history of botany.

Work in Embryology. Difficult as was his work in insect anatomy and plant histology, a more difficult one remains to be mentioned, viz., his observations on the development of animals. He had pushed his researches into the finer structure of organisms, and now he attempted to answer this question: How does one of these organisms begin its life, and by what series of steps is its body built up? He turned to

the chick, as the most available form in which to get an insight into this process, but he could not extend his observations successfully into periods earlier than about the twenty-four hour stage of development. Two memoirs were written on this subject, both in 1672. Of all Malpighi's work, this has received the least attention from reviewers, but it is, for the time, a very remarkable piece of work. No one can

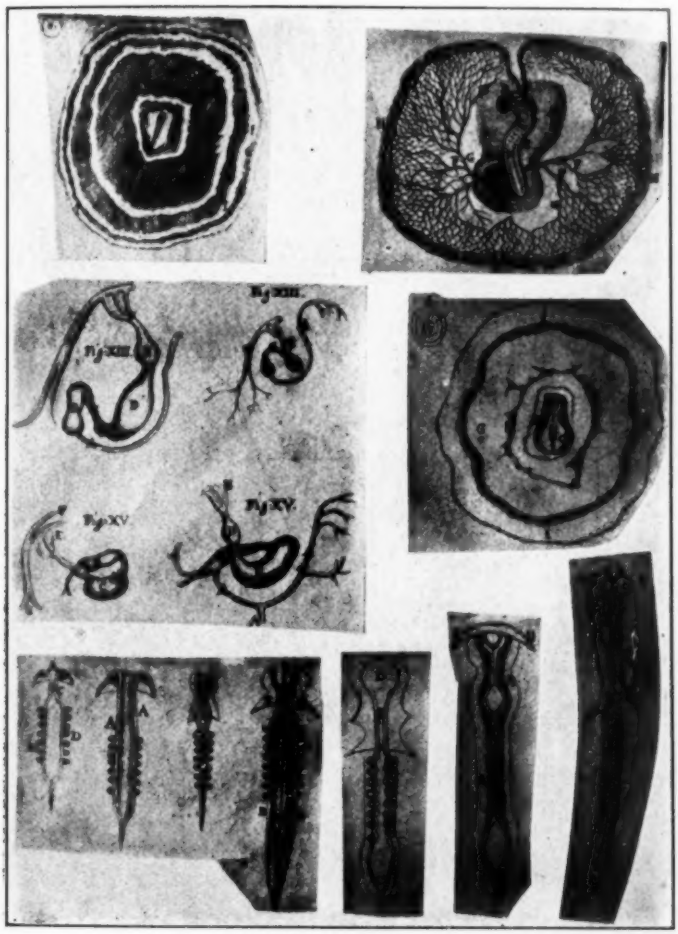


FIG. 3. MALPIGHI'S SKETCHES SHOWING THE EMBRYOLOGICAL DEVELOPMENT OF THE CHICK.

look over the ten folio plates without being impressed with the extent and accuracy of his observations. His earliest sketches show an open neural groove with an enlargement for the head end, and from this stage onward he carries the development of the chick by sketches to the period of hatching. These sketches are of interest not only to students of embryology, but also to educated people, to see how far

observations upon the development of animals had progressed in 1672. His are, doubtless, the earliest figures ever made showing the comparatively early stages of development. Harvey's observations on development, published in 1631, were not accompanied by illustrations, and the sketches of Fabricius, *ab aqua pendente*, published in 1604, were far surpassed by Malpighi's, the youngest stages represented being much older than his.

Fig. 3 shows a group of selected sketches from different plates, but they fail to give an adequate idea of the extent of the work, taken as a whole. It is very interesting to note the figures showing the formation of the heart and aortic arches. The execution of the figures in this work is less coarse than those on the silkworm.

The embryological thought of his time was dominated by the theory of preformation or predelineation. Just as when we examine a seed, we find within an embryo plantlet, so it was supposed that the minute embryos of all animal life existed in miniature within the egg. Harvey had expressed himself against it, and the doctrine was overthrown by Wolff in the following century. Malpighi's position, however, was based on actual observation; he was not able to find by examination any stage in which there was no evidence of organization. Dareste says that he examined eggs in a very hot August, in which there is reason to believe that developmental changes had gone forward to a considerable degree. Be this as it may, the imperfection of his instruments and methods would have made it very difficult to have seen anything definitely in stages below twenty-four hours. As a result of his experience, he says:

"When we undertake to discover the principle of life of animals in the egg we are astonished to find the animal already formed there; thus our labor is vain, for as soon as we encounter the first movement of life we are obliged to recognize parts that are visible to our eyes. * * * On this account, it may be necessary to declare that the first beginnings preexist in the egg," etc. In his posthumous works he "is less circumspect, and goes even to the point of describing the mechanism of evolution of these primitive elements."

Malpighi was a naturalist, but of a new type; he began to look below the surface, and essayed a deeper level of analysis, in observing and describing the internal and minute structure of animals and plants, and when he took the further step of investigating their development he was anticipating the work of the nineteenth century.

JOHN SWAMMERDAM. 1637-1680.

Swammerdam was a different type of man—nervous, incisive, very intense, stubborn and self-willed. Much of his character shows in the

portrait by Rembrandt. Although its authenticity has been questioned, it is the only portrait* known of Swammerdam.

He was born in 1637, nine years after Malpighi. His father, an apothecary of Amsterdam, had a taste for collecting, which was shared

FIG. 4. JAN SWAMMERDAM.

by many of his fellow-townsmen. "The vast commerce and extended colonial empire of the Holland of that day fostered the formation of private museums." The elder Swammerdam had the finest and most

* I am indebted to Professor Dr. Hoffman, of Leyden, for this copy.

celebrated collection in all Amsterdam. This was stored, not only with treasures, showing the civilization of remote countries, but, also, with specimens of natural history, for which he had a decided liking. Thus "from the earliest dawn of his understanding the young Swammerdam was surrounded by zoological specimens, and from the joint influence, doubtless, of hereditary taste and early association, he became passionately devoted to the study of natural history."

His father intended him for the church, but he had no taste for divinity, though he became a fanatic in religious matters towards the close of his life; at this period he could brook no restraint in word or action. He consented to study medicine, but for some reason he was twenty-six years old before entering the University of Leyden. This delay was very likely due to his precarious health, but, in the meantime, he had not been idle; he had devoted himself to observation and study with great ardor, and had already become an expert in minute dissection. When he went to the University, therefore, he at once took high rank in anatomy. Anything demanding fine manipulation and skill was directly in his line.

At Leyden he studied anatomy under the renowned Sylvius and surgery under Van Horne. He also continued his studies in Paris, and about 1667 took his M. D. degree.

During this period of medical study he made some rather important observations in human anatomy, and introduced the method of injection that was afterwards claimed by Ruysch. In 1664 he discovered the values of lymphatic vessels by the use of slender glass tubes and, three years later, first used a waxy material for injecting blood vessels.

It should be noted, in passing, that Swammerdam was the first to observe and describe the blood corpuscles. As early as 1658 he described them in the blood of the frog, but his observations were not published till fifty-seven years after his death by Boerhaave, and, therefore, he does not get the credit of this discovery. Publication alone establishes priority, not first observation, but there is conclusive evidence that he observed the blood corpuscles before either Malpighi or Leeuwenhoek had published their observations.

After graduating in medicine he did not practise, but followed his strong inclination to devote himself to minute anatomy. This led to differences with his father, who insisted on his going into practise, but the self-willed stubbornness and firmness of his nature showed themselves. It was from no love of ease that Swammerdam thus held out against his father, but to be able to follow an irresistible leading towards minute anatomy. At last his father was planning to stop supplies, in order to force him into the desired channel, but Swammerdam made efforts, without success, to sell his own personal collection and preserve his independence. His father died, leaving him sufficient property to live

on, and brought the controversy to a close soon after the son had consented to yield to his wishes.

Boerhaave, his fellow-countryman, gathered his complete writings after his death and published them in 1737 under the title 'Biblia Naturæ.' This is preceded by a life of Swammerdam, in which a graphic account is given of his phenomenal industry, his intense application, his methods and instruments. Most of the following passages are selected from that work.

He was a very intemperate worker, and in finishing his treatise on bees (1673) he broke himself down.

"It was an undertaking too great for the strongest constitution to be continually employed by day in making observations and almost as constantly engaged by night in recording them by drawings and suitable explanations. This being summer work, his daily labors began at 6 in the morning, when the sun afforded him light enough to enable him to survey such minute objects; and from that time till 12 he continued without interruption, all the while exposed in the open air to the scorching heat of the sun, bareheaded, for fear of interrupting the light, and his head in a manner dissolving into sweat under the irresistible ardors of that powerful luminary. And if he desisted at noon it was only because the strength of his eyes was too much weakened by the extraordinary efflux of light and the use of microscopes to continue any longer upon such small objects.

"This fatigue our author submitted to for a whole month together, without any interruption, merely to examine, describe and represent the intestines of bees, besides many months more bestowed upon the other parts; during which time he spent whole days in making observations, as long as there was sufficient light to make any, and whole nights in registering his observations, till at last he brought his treatise on bees to the wished-for perfection.

"For dissecting very minute objects, he had a brass table made on purpose by that ingenious artist, Samuel Musschenbroek. To this table were fastened two brass arms, movable at pleasure to any part of it, and the upper portion of these arms was likewise so contrived as to be susceptible of a very slow vertical motion, by which means the operator could readily alter their height as he saw most convenient to his purpose. The office of one of these arms was to hold the little corpuscles, and that of the other to apply the microscope. His microscopes were of various sizes and curvatures, his microscopical glasses being of various diameters and focuses, and from the least to the greatest, the best that could be procured, in regard to the exactness of the workmanship and the transparency of the substance.

"But the constructing of very fine scissors, and giving them an extreme sharpness, seems to have been his chief secret. These he made use of to cut very minute objects, because they dissected them equably, whereas knives and lancets, let them be ever so fine and sharp, are apt to disorder delicate substances. His knives, lancets and styles were so fine that he could not see to sharpen them without the assistance of the microscope; but with them he could dissect the intestines of bees

with the same accuracy and distinctness that others do those of large animals.

"He was particularly dexterous in the management of small tubes of glass no thicker than a bristle, drawn to a very fine point at one end, but thicker at the other."

These were used for inflating hollow structures and also for making fine injections. He dissolved the fat of insects in turpentine and carried on dissections under water.

An unbiased examination of his work will show that it is of a higher quality than Malpighi's in regard to critical observation and richness in detail. He also worked with minuter objects and displayed a greater skill. As one writer says:

"He had in the highest degree all the attributes which mark the eminent observer. In delicate and subtle manipulation, in contriving new methods to meet every case, in acute and accurate perception, he has never been surpassed and rarely equaled."

United with these exceptional talents as an observer was a mystical quality of mind that made his interpretations less happy, and often led him to strange ideas. It is an interesting psychological combination. His observations are accurate, but his interpretations fanciful. For instance, in observing the transformations of insects, he came to a stage in which he could see the parts of the adult insect encased, as it were, in the pupa. This led him to see, in fancy, an evidence of encasement of one generation within another in all animals and to adhere to that curious idea of *emboitement*, which had so many believers in his time. He even saw in this the proof, to his mind, that the germs of all forthcoming generations of mankind were originally located in the common mother Eve, all closely encased one within the other, like the boxes of a Japanese juggler. The end of the world was by him conceived of as a necessity when the last germ of this wonderful series had become unfolded.

The last part of his life was dimmed by fanaticism. He read the works of Antoinette Bourignon and fell under her influence; he began to subdue his warm and stubborn temper, and to give himself up to religious contemplation. She taught him to regard scientific research as worldly, and, following her advice, he gave up his passionate fondness for studying the works of the Creator, to devote himself to loving and adoring that same Being. Always extreme and intense in everything he undertook, he likewise overdid this, and yielded himself to a sort of fanatical worship until the end of his life, in 1680. Had he possessed a more vigorous constitution, he would have been greater as a man. He lived, in all, but forty-three years; the last six or seven years were unproductive from his mental distractions, and before that much of his time had been lost by sickness.

It is time to ask, with all his talents and prodigious application, what did he leave to science? This is best answered by an examination of the 'Biblia Naturæ,' into which all his work was collected. His treatise on 'Bees and Mayflies' and a few other articles were published during his lifetime, but a large part of his observations remained entirely unknown until they were published in this book fifty-seven years after his death. In the folio edition it embraces 410 pages of text and fifty-three plates, replete with figures of original observations. It "contains about a dozen life-histories of insects worked out in more or less detail. Of these, the Mayfly is the most famous; that on the honeybee the most

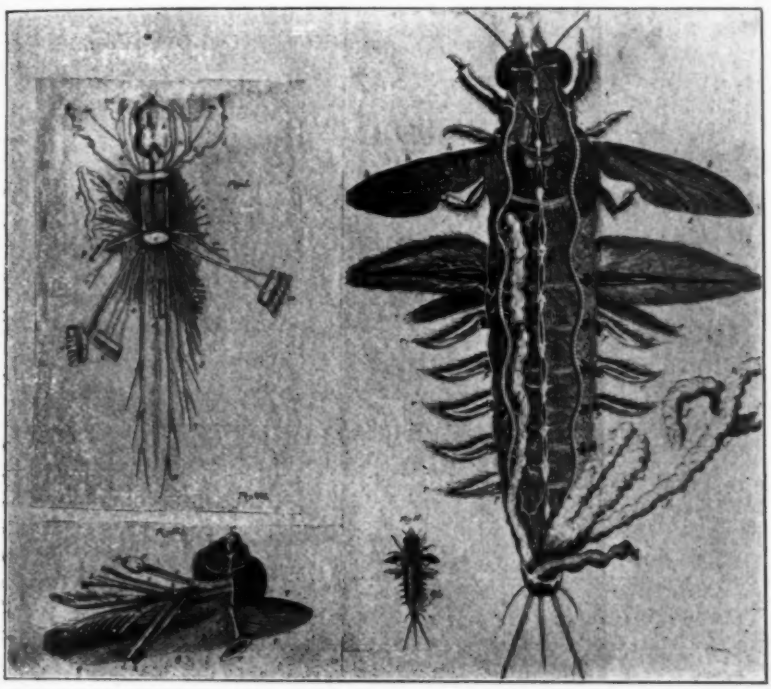


FIG. 5. FROM SWAMMERDAM'S 'BIBLIA NATURÆ.'

elaborate." The greater amount of his work was in structural entomology. It is known that he had a collection of about 3,000 different species of insects, which for that period was a very large one. There is, however, a considerable amount of work on other animals: the fine anatomy of the snail, structure of the clam, the squid; observations on the structure and development of the frog; observations on the contraction of muscles, etc., etc.

It is to be remembered that Swammerdam was extremely exact in all that he did. His descriptions are models of accuracy and completeness.

Fig. 5 shows reduced sketches of his illustrations of the structure of the snail, and also of the larva of an insect. The upper sketch on the left-hand side shows the central nervous system and the nerve trunks connected therewith, and the lower figure on the same side shows the shell and the principal muscles. This is an exceptionally good piece of anatomical work for the time, and is a fair sample of the fidelity with which he worked out details in the structure of small animals. Besides showing this, these figures also serve the purpose of pointing out that Swammerdam's fine anatomical work was by no means confined to insects. His work on the structure of the young frog was equally noteworthy.

But we should have at least one illustration of his handling of insect anatomy to compare more directly with that of Malpighi, already given (p. 567). The right-hand side of Fig. 5 is a reduced sketch of the anatomy of the larva of an ephemerus, compared with the work of Malpighi; we see there a more masterly hand at the work, and a more critical spirit back of the hand. The nervous system is very well done, and the greater detail in other features shows a disposition to go into the work deeper than Malpighi.

Besides work on structure and life histories, Swammerdam showed, experimentally, the irritability of nerves and the response of muscles after their removal from the body. He not only illustrates this quite fully, but seems to have had a pretty good appreciation of the nature of the problem of the physiologist. He says:

"It is evident from the foregoing observations that a great number of things concur in the contraction of the muscles, and that one should be thoroughly acquainted with that wonderful machine, our body, and the elements with which we are surrounded, to describe exactly one single muscle and explain its action. On this occasion it would be necessary for us to consider the atmosphere, the nature of our food, the blood, the brain marrow and nerves, that most subtle matter which instantaneously flows to the fibers, and many other things, before we could expect to attain a sight of the perfect and certain truth."

In reference to the formation of animals within the egg, Swammerdam was, as Malpighi, a believer in the preformation theory. The basis for his position on this question has already been stated.

There was another question in his time upon which philosophers and scientific men were divided, that was in reference to the origin of living organisms: Does lifeless matter, sometimes, when submitted to heat and moisture, spring into life? Did the rats of Egypt come, as the ancients believed, from the mud of the Nile, and do frogs and toads have a similar origin? Do insects spring from the dew on plants? etc., etc. The famous Redi had performed his noteworthy experiments the year after Swammerdam's birth, but opinion was divided upon the question as to the possible spontaneous origin of life, especially among

the smaller animals. Upon this question, Swammerdam took a positive stand; he ranged himself on the side of the more scientific naturalists against the spontaneous origin of life. In reference to this matter he says:

"In attentively examining the development of insects, of animals with blood, and vegetables, one recognizes that all these beings grow and develop according to one law, and one feels how false is the opinion that attributes to fortuitous causes such regular and constant effects."

FIG. 6. ANTONIUS A. LEEUWENHOEK.

ANTONY VAN LEEUWENHOEK. 1632-1723.

In Leeuwenhoek we find a composed and better balanced man. Blessed with a vigorous constitution, he lived ninety-one years, and worked to the end of his life. He was born in 1632, four years after Malpighi and five before Swammerdam; they were, therefore, strictly speaking, contemporaries. He stands in contrast with the other men in being self-taught; he did not have the advantage of a university training, and apparently never had a master in scientific studies. This lack of systematic training shows in the desultory character of his extensive observations. Impelled by the same gift of genius that drove

his confrères to study nature with such unexampled activity, he, too, followed the path of an independent and enthusiastic investigator.

The portrait which forms a frontispiece to his 'Arcana Naturæ' represents him at the age of sixty-three, and shows the pleasing countenance of a firm man in vigorous health. Richardson says: "In the face peering through the big wig there is the quiet force of Cromwell and the delicate disdain of Spinoza." "It is a mixed racial type, Semitic and Teutonic, a Jewish-Saxon; obstinate and yet imaginative; its very obstinacy a virtue, saving it from flying too far wild by its imagination."

There was a singular scarcity of facts in reference to Leeuwenhoek's life until 1885, when Dr. Richardson published in 'The Asclepiad'* the results of researches made by Mr. A. Wynter Blyth in Leeuwenhoek's native town of Delft. I am indebted to that article for much that follows.

His 'Arcana Naturæ' and other scientific letters contained a complete record of his scientific activity, but 'about his parentage, his education and his manner of making a living there was nothing but conjecture to go upon.' The few scraps of personal history were contained in the 'Encyclopædia' articles by Carpenter and others, and these were wrong in sustaining the hypothesis that Leeuwenhoek was an optician or manufacturer of lenses for the market. Although he ground lenses for his own use, there was no need on his part of increasing his financial resources by their sale. He held under the court a minor office designated 'Chamberlain of the Sheriff.' The duties of the office were those of a beadle, and were set forth in his commission, a document still extant. The requirements were light, as was also the salary, amounting to about £26 a year. He held this post for thirty-nine years, and the stipend was thereafter continued to him to the end of his life.

Van Leeuwenhoek was derived from a good Delft family. His grandfather and great-grandfather were Delft brewers, and his grandmother a brewer's daughter. The family doubtless were wealthy. His schooling seems to have been brought to a close at the age of sixteen, when he was 'removed to a clothing business in Amsterdam, where he filled the office of bookkeeper and cashier.' After a few years he returned to Delft, and at the age of twenty-two he married and gave himself up largely to studies in natural history. Six years after his marriage he obtained the appointment designated above. He was twice married, but left only one child, a daughter by his first wife.

He led an easy, prosperous, but withal a busy life. The microscope had recently been invented, and for observation with that new instrument Leeuwenhoek showed an avidity amounting to a passion.

* 'Leeuwenhoek and the Rise of Histology.' Asclepiad, Vol. II.: 1885.

"That he was in comfortable if not affluent circumstances is clear from the character of his writings; that he was not troubled by any very anxious and responsible duties is certain from the continuity of his scientific work; that he could secure the services of persons of influence is discernible from the circumstances that, in 1673, De Graaf sent his first paper to the Royal Society of London; that in 1680 the same society admitted him as fellow; that the directors of the East India Company sent him specimens of natural history, and that, in 1698, Peter the Great paid him a call to inspect his microscopes and their revelations."

Leeuwenhoek seems to have been fascinated by the marvels of the microscopic world, but the extent and quality of his work lifted him above the level of the dilettante. He was not, like Malpighi and Swammerdam, a skilled dissector, but turned his microscope in all directions; in the mineral, as well as the vegetable and animal kingdoms. Just when he began to use the microscope is not known; his first publication in reference to microscopic objects did not appear till 1673, when he was forty-one years old. He gave good descriptions and drawings of his instruments, and those still in existence have been described by Carpenter and others, and, therefore, we have a very good idea of his working equipment. During his lifetime he sent as a present to the Royal Society of London twenty-six microscopes, each provided with an object to examine. Unfortunately, these were removed from the rooms of the society and lost during the eighteenth century. His lenses were of fine quality and were ground by himself. They were nearly all simple lenses of small size, but considerable curvature, and needed to be brought close to the object examined. He had different microscopes for different purposes, giving a range of magnifying powers from 40 to 270 diameters and possibly higher. The number of his lenses is surprising; he possessed not less than 247 complete microscopes, two of which were provided with double lenses and one with a triplet. In addition to the above he had 172 lenses set between plates of metal, which gives a total of 419 lenses used by him in his observations. Three were of quartz, or rock crystal, the rest were of glass. More than one-half the lenses were mounted in silver, three were in gold.

It is to be understood that all his microscopes were of simple construction; no tubes, no mirror; simply pieces of metal to hold the magnifying-glass and the objects to be examined, with screws to adjust the position and the focus. We shall perhaps get the best idea of how they were used and brought into focus by reference to Fig. 7, which is copied from Richardson's article in 'The Asclepiad.' This shows the way the instrument was arranged to examine the circulation of blood in the transparent tail of a small fish. The fish was placed in water in a slender glass tube, and the latter was held in a metallic frame, to

which a plate (marked D) was joined, carrying the magnifying glass. The latter is indicated in the circle above the letter D, near the tail-fin of the fish. The eye was applied close to this circular magnifying-glass, which was brought into position and adjusted by means of screws. The two small sketches show a front and a back view of another one of his microscopes. The small circle shows the position of the lens inserted in a metallic plate. On the opposite side was a sort of object holder, whose position was controlled by screws. In some instances, he had a concave reflector with a hole in the center, in which his magni-

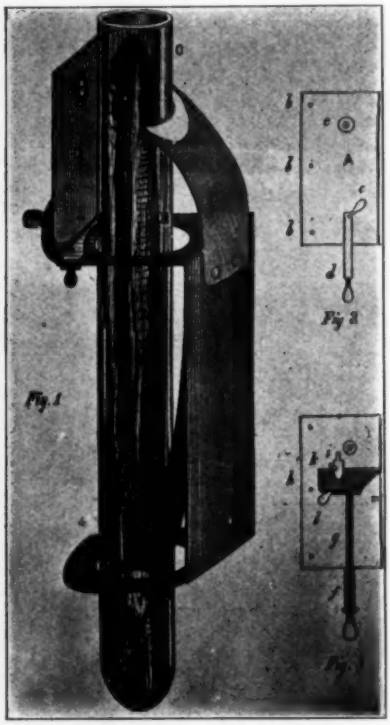


FIG. 7. LEEUWENHOEK'S MICROSCOPE.

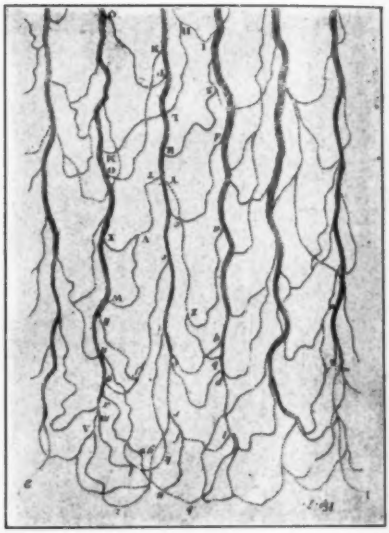


FIG. 8. CAPILLARY CIRCULATION, AFTER LEEUWENHOEK.

fying-glass was inserted, and, in this form of the instrument, the objects were illuminated by reflected and not by transmitted light.

His microscopic observations were described and sent to learned societies in the form of letters. "All or nearly all that he did in a literary way was after the manner of an epistle," and these were so numerous as to justify the cognomen, 'The man of many letters.' "The French Academy of Sciences, of which he was elected a corresponding member in 1697, got twenty-seven; but the lion's share fell to the young Royal Society of London, which in fifty years—1673-1723—re-

ceived 375 letters and papers." "The works themselves, except that they lie in the domain of natural history, are disconnected and appear in no order of systematized study. The philosopher was led by what transpired at any moment to lead him."

In 1686 he observed the minute circulation and demonstrated the capillary connection between arteries and veins. This was perhaps his most important observation for its bearing on physiology. It must be remembered that Harvey had not actually seen the circulation of the blood, which he announced in 1628. He assumed on entirely sufficient grounds the existence of a complete circulation, but there was wanting in his scheme the direct ocular proof of the passage of blood from arteries to veins. This was supplied by Leeuwenhoek. Fig. 8 shows one of his sketches of the capillary circulation. In his efforts to see the circulation he tried various animals; the comb of the young cock, the ears of white rabbits, the membraneous wing of the bat were progressively examined. The next advance came when he directed his microscope to the tail of the tadpole. Upon examining this he exclaims:

"A sight presented itself more delightful than any mine eyes had ever beheld; for here I discovered more than fifty circulations of the blood, in different places, while the animal lay quiet in the water, and I could bring it before my microscope to my wish. For I saw not only that in many places the blood was conveyed through exceedingly minute vessels, from the middle of the tail towards the edges, but that each of the vessels had a curve or turning, and carried the blood back towards the middle of the tail, in order to be again conveyed to the heart. Hereby it plainly appeared to me that the blood-vessels which I now saw in the animal, and which bear the names of arteries and veins, are, in fact, one and the same; that is to say, that they are properly termed arteries so long as they convey the blood to the furtherest extremities of its vessels, and veins when they bring it back to the heart. And thus it appears that an artery and a vein are one and the same vessel prolonged or extended."

This description shows that he fully appreciated the course of the minute vascular circulation and the nature of the communication between arteries and veins. He afterwards extended his observations to the web of the frog's foot, the tail of young fishes and eels.

In this connection it should be remembered that Malpighi, in 1661, observed the flow of blood in the lungs and mesentery of the frog, but he made little of it. Leeuwenhoek did much more with his discovery, and gave the first clear idea of the capillary circulation. Leeuwenhoek was also anticipated by Malpighi in reference to the microscopic structure of the blood. (See also under Swammerdam.) To Malpighi the corpuscles appeared to be globules of fat, while Leeuwenhoek noted that the blood discs of birds, frogs and fishes were oval in outline and

those of mammals circular. He reserved the name of 'globule' for those of the human body, erroneously believing them to be spheroidal.

Among his other discoveries bearing on physiology and medicine may be mentioned: The branched character of heart muscles, the stripe in voluntary muscles, the structure of the crystalline lens, the description of spermatozoa after they had been pointed out to him in 1674 by Hamen, a medical student in Leyden, etc. Richardson dignifies him with the title, 'The Founder of Histology,' but this, in view of the work of his great contemporary, Malpighi, seems to me an overestimate.

Turning his microscope in all directions, he examined water and found it peopled with minute animalcules, those simple forms of animal life, propelled through the water by innumerable hair-like cilia, extending from the body like banks of oars from a galley, except that in many cases they extend from all surfaces. He saw not only the animalcules, but also the cilia that move their bodies.

His descriptions of the various forms of these animalcules are interesting, and in strangely archaic language. Here is one of them, changed from Dutch into English:

"In the year 1675 I discovered living creatures in rain-water which had stood but four days in a new earthern pot, glazed blew within. This invited me to view this water with great attention, especially those little animals appearing to me ten thousand times less than those represented by Mons. Swammerdam, and by him called waterflies or waterlice, which may be perceived in the water with the naked eye. The first sort by me discovered in the said water, I divers times observed to consist of five, six, seven or eight clear globules, without being able to discover any film that held them together or contained them. When these *animalcula*, or living atoms, did move they put forth two little horns, continually moving themselves; the place between these two horns was flat, though the rest of the body was roundish, sharpening a little towards the end, where they had a tayle, near four times the length of the whole body, of the thickness (by my microscope) of a spider's web; at the end of which appeared a globule, of the bigness of one of those which made up the body; which tayle I could not perceive even in very clear water to be mov'd by them. These little creatures, if they chanced to light upon the least filament or string, or other such particle, of which there are many in the water, especially after it has stood some days, they stook entangled therein, extending their body in a long round, and striving to dis-entangle their tayle; whereby it came to pass, that their whole body lept back towards the globule of the tayle, which then rolled together serpent-like, and after the manner of copper or iron wire, that having been wound around a stick, and unwound again, retains those windings and turnings,"* etc.

"Any one who has examined under the microscope the well-known bull animalcule will recognize in this first description of it the stalk

* 'Kent's Manual of the Infusoria.' Vol. 1, p. 3. Taken from the 'Philosophical Transactions' for the year 1677.

and its form after contraction in the 'tayle which retains those windings and turnings.'

He discovered also the Rotifers, those favorites of the amateur microscopists, made so familiar to the general public in works like Gross's 'Evenings at the Microscope.' He showed their remarkable powers of resuscitation after complete drying. He observed that when water containing these animalcules evaporated they were reduced to fine dust, but became alive again after great lapses of time by the introduction of water.

He made many observations on the microscopic structure of plants. Fig. 9 gives a fair sample of the extent to which he observed the cellular construction of vegetables and anticipated the cell-theory.

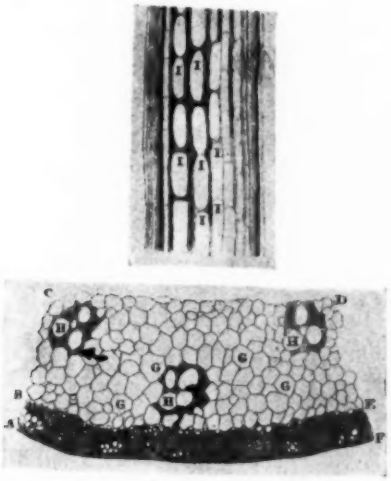


FIG. 9. FROM LEEUWENHOEK'S 'ARCANA NATURÆ.'

While Malpighi's work in that field was more extensive, these sketches from Leeuwenhoek represent very well the character of the work of the period on minute structure of plants.

It remains to say that on the two biological questions of the day he took a decided stand. He was a believer in preformation or predelineation of the embryo in an extreme degree, seeing in fancy the complete outline of both maternal and paternal individuals in the spermatozoa, and going so far as to make sketches of the same. But upon the question of the spontaneous origin of life he took the side that has been so triumphantly demonstrated in this century against the occurrence of spontaneous generation.

We see in these three gifted contemporaries different personal characteristics. Leeuwenhoek, the composed and strong, attaining an age

of ninety-one; Malpighi, always in feeble health, but directing his efforts with rare capacity, reaching the age of sixty-seven; while the great intensity of Swammerdam stopped his scientific career at thirty-six and burned out his life at the age of forty-three.

They were all original and accurate observers, but there is variation in the kind and quality of their intellectual product. The two university-trained men showed capacity for coherent observations; they were both better able to direct their efforts towards some definite end; Leeuwenhoek, with the advantages of vigorous health and long working period, lacked the systematic training of the schools, and all his life worked in discursive fashion; he left no coherent piece of work of any extent like Malpighi's 'Anatome Plantarum' or Swammerdam's 'Anatomy and Metamorphosis of Insects.'

Swammerdam was the most critical observer of the three, if we may judge by his work in the same field as Malpighi's on the silkworm. His descriptions are models of accuracy and completeness, and his anatomical work shows a higher grade of finish and completeness than Malpighi's. Malpighi, it seems to me, did more in the sum total than either of the others to advance the sciences of anatomy and physiology and through them the interests of mankind. Leeuwenhoek had larger opportunity; he devoted himself to microscopic observations, but he wandered over the whole field. While his observations lose all monographic character, nevertheless they were important in opening new fields and advancing the sciences of anatomy, physiology, botany and zoology.

The combined force of their labors marks an epoch in the establishment of the scientific method and in the ushering in of a new grade of intellectual life.

TWO CONTEMPORARY PROBLEMS IN EDUCATION.

BY PROFESSOR PAUL H. HANUS,
HARVARD UNIVERSITY.

TWO of the important problems that the contemporary interest in education has brought prominently before the public are I. What shall we do about the elective system of studies which is daily extending its sway over schools and colleges throughout the country? and II. How shall we bridge the gap between the high school and the lower grades; *i. e.*, how shall we minimize the waste in the pupil's school education, and make his entire school career serve continuously and progressively—as it should—his gradually expanding interests, needs, powers, and duties?

I.

It is well known that even those secondary schools and colleges which do not recognize electives, as such, and cling to 'courses of study,' permit not merely a choice between different 'courses,' but they also, usually, permit substitutions of studies in one 'course' for studies in another; so that, really, if not nominally, a considerable range of choice, or election of studies, is permitted in most secondary schools and colleges nearly everywhere throughout the country.

Both experience and observation seem to justify this widespread adoption of the elective system, in some form, in secondary schools and colleges. During the years of secondary school and college education the pupil passes through the important stage of adolescence and youth. He emerges from childhood to manhood. During these years he may be, and should be, led to self-revelation, and he should be aided to organize his mental life in accordance with his dominant interests and capacities, both for vocational and extra-vocational activities. After an individual's interests have emerged distinctly, all voluntary effort is reserved for his preferences; and that achievement is most productive when it is based on interests and capacity, need not be argued. Daily experience proves that an individual's dominant interests ultimately determine the extent of his private and public usefulness and the sources of his pleasures—that, in short, they determine the richness or the poverty of his life, in the broadest sense of those words.

If this be admitted, the importance of discovering and cultivating a youth's dominant interests is apparent. He should, therefore, choose

his own curriculum as soon as possible. He can learn to choose wisely only by choosing repeatedly, under guidance, as wisely as possible. Hence, although a child twelve or thirteen years old should not freely choose his own courses of study, he is, nevertheless, entitled to have his preferences considered in the choices which his parents and teachers permit him to make. As he grows older, his ability to choose wisely should be deliberately cultivated, so that usually, by the time he has completed his secondary-school education—rarely before that time—he may be prepared to choose his further studies without restrictions. A youth of eighteen or nineteen, who has been learning to choose, who has had training in foresight for five or six years, is not likely to abuse his privileges, nor is he likely to be ignorant of the importance of wise counsel, nor to wish to dispense with it.

But it may be said that if a youth is allowed to choose his own studies, he is not trained to 'work against the grain.' I am not sure that I understand the meaning attached to this phrase by those who use it. But, in my opinion, the only sense in which any sane person, in adult life, works 'against the grain,' is when he applies himself to a disagreeable or even repulsive task for the sake of some ultimate end that is intrinsically agreeable to him, or recognized as good by him. There is no other working against the grain worth cultivating. No one, not even an ascetic, habitually does disagreeable things for their own sake.

When an adult works faithfully at a disagreeable task, he does it primarily because it is clear to him that his personal interests are at stake—that his daily bread, or honor, or social elevation, depends on the performance of his work or his duty, however disagreeable it may be. In other words, there are strong extraneous motives, *the force of which he can appreciate*, that cause him to apply himself to the uninviting or repelling task before him. True, many a man does live his life under just such disadvantageous conditions. But it is a life of mere drudgery, from which he might have been saved if he had learned in youth to choose that calling which is in harmony with his dominant interests and capacities. His work might then have been hardly less a pleasure than his leisure, and he would, of course, have been a more useful member of society, and would have earned more leisure, because of the increased efficiency of his work.

But can any one with any knowledge of boy nature assert that faithful application to the positively and permanently uninteresting can be cultivated by extraneous motives, even if it were desirable? The motives which appeal to the adult are meaningless to the boy. Moreover, he feels instinctively that consciousness was added to the equipment of mankind, in the process of human evolution, for guidance, and he insists as long as he can on using it for that purpose. The remote reasons which apparently weigh heavily against the pupil's strong

disinclination in the minds of his governors do not and cannot appeal to him as intrinsically valid. One can, of course, compel the performance of disagreeable tasks, and by repetition of compulsion one can convince a refractory youth that *some* achievement is always possible and necessary, in spite of his strong aversion to a particular kind of work. But what one usually cultivates, under such circumstances, is not a growing strength to master difficulties, but chiefly the habit of skilful, even of subtle evasion—the habit of calculating not how much one can do, but how little one must do.

Again, the effect of compelling a youth to pursue a subject permanently uninteresting is pernicious in another way. It cultivates the abominable habit of being satisfied with partial or inadequate achievement. Permanent lack of interest in a given field of work is an indication of corresponding incapacity; for growing interest and capacity always go together. Under such circumstances a youth never feels the glow of conscious mastery of the subject for its own sake; half achievement is the result of forced, half-hearted endeavor, and both become the rule.

The result may be even worse. To be constantly baffled undermines one's confidence in one's own powers, and ultimately imperils self-respect. To force a youth to work against the grain for its own sake is, therefore, futile, and worse than futile; for it not only fails to accomplish its purpose, but actually cultivates the evasion of school work, the aversion to school work, and, in extreme cases, it may even destroy the capacity for work of any sort. Morever, it must not be forgotten that evasion of work, aversion to work, and *ennui* are the fertile soil in which all the vices flourish.

Again, all such efforts to make a youth work 'against the grain,' for its own sake, by the pursuit of uninteresting studies are artificial, and wholly unnecessary. What we want a youth to acquire is the power of overcoming difficulties, and the corresponding habit of adequate achievement. This power and the corresponding habit are cultivated *by overcoming difficulties*, not by forced and *unsuccessful attempts* at overcoming them. Every subject affords abundant opportunity for overcoming difficulties, and when it is in harmony with the pupil's interests and powers, those difficulties *will be overcome*; first, because they lie in the way of further progress in a subject which he wishes to master; and second, because he possesses the requisite natural capacity for conquest, because he daily feels the *sense of achievement*—the strongest of all incentives to exertion. Hence, conquest may become the rule. Through conquest alone comes the habit of *working in spite of difficulties*, which is the kind of working against the grain worth trying for.

Finally, as was pointed out above, a man's life is more significant and richer in every way, the more his dominant interests and powers

determine both his serious pursuits and his refined pleasures. The natural preferences of pupils during the stage of secondary education should, therefore, be *heeded*, not thwarted. There is no other effective way to cultivate the habit of 'working against the grain' in the only sense in which such work is wise. It is no argument to say that generations of men have been trained to work against the grain under rigidly prescribed programs of study. The sufficient reply to such an argument is already contained in what has been said about the relative effect of extraneous motives in youth and in adult life. It may be added, therefore, that this capacity where it exists has been developed in spite of, not because of, the rigid prescription of studies.

Of course, nothing that has been said applies to shirking. The shirk deserves no concessions, and should have no mercy. What the pupil has chosen to do, both the home and the school must insist that he *shall* do.

The question about elective studies is, accordingly, not 'shall we recognize electives?' That question has been answered in the affirmative. The question is, 'What is the wisest administration of electives in secondary education?' While each school is seeking the answer to this question in its own way, there is substantial agreement on one point: namely, that there should be restriction on the pupil's freedom to choose his own curriculum of studies. But opinions vary widely as to what these restrictions shall be, and how they shall be administered. I hold that these restrictions should be as few as are consistent with his permanent welfare. To prevent the harm which might result from the pupil's ignorance and immaturity—to guard against the possibility of the pupil's cutting himself off from an illuminating acquaintance with nature and her ways on the one hand, and the historical culture of the race, as embodied in books, social institutions and art, on the other, some of the secondary school pupil's work must be prescribed. To insure that training in choice that was emphasized a moment ago, and the best possible preparation for complete living in the fullest sense of the term, a considerable part of the instruction should be offered without other restrictions than those of sequence and amount. The fundamental questions are, of course, what studies shall we prescribe for all pupils, and when shall we permit a pupil to discontinue a study once undertaken?

The experience of teachers who have worked under both prescribed and elective systems seems to point conclusively to the fact that no study, however highly esteemed by parents or teachers, will be a real influence in the pupil's development, and so contribute to his future usefulness and happiness in any important way, unless it is, in some degree at least, intrinsically interesting to him. Hence, no pupil should be required to pursue a study after it is clear that it does not

appeal to him. Under most circumstances one year is enough—and it is not too much—to ascertain whether a study does, or does not, really challenge a youth's interest and capacity. Hence, to answer the second of the two questions just proposed, first, I should say that, in general, after a pupil has made his choice of a study, he should be required to pursue it for a year. As to the first question, namely, What studies shall be prescribed for all? it seems to me clear that no youth should be allowed, through ignorance or caprice, to cut himself off from any one of the great sources of human inspiration and guidance. If we could rely on having a varied and substantial program of studies during the pre-high-school years, some of the prescriptions I am about to suggest might well be omitted: notably the mathematics. But as long as the pre-high-school grades, even those immediately preceding the high-school grades, cannot yet be seriously regarded as the beginning of high-school education in most school systems—among them some of the best in the country—in order to guard against the blindness of ignorance when pupils come up to the high school, it is necessary to insist on a considerable amount of prescription.

I would, therefore, prescribe for every non-collegiate pupil, during his secondary school career, at least one year of the study of his mother tongue, giving most of the time to literature with its inspiring and guiding influences; at least one year of science, so taught as to show the pupil how man is coming to master nature by understanding her, and at the same time, also, how completely one who knows nothing of natural science is cut off from participation in some of the most interesting, profound and far-reaching problems of contemporary thought; one year of a modern foreign language, through which he may learn to appreciate fully his mother tongue, and through which at the same time he may widen his mental horizon so as to include ultimately the literature, the institutional life, the ideals in a word, the intellectual resources of another modern nation besides his own; one year of history—English or American—so taught as to show the meaning of democratic institutions and the means of safeguarding and improving them. If American history is prescribed, I would have it so taught as to fill the pupil's mind with the most important truths about what his country is, and what it really stands for; not glossing over its past and present defects and unduly exalting its merits, but bringing into strong relief our worthiest political ideals, and laying special emphasis on the lesson that the approximate realization of worthy political ideals has always been and still is possible only through the intelligent participation of citizens in public affairs, not primarily as office holders, but still more as alert and active private citizens; to do this, not so much by didactic instruction or exhortation, as by the inevitable logic of events skilfully portrayed; I would prescribe, further, one year of the history of

industry and commerce, together with the elements of civics treated historically, that the pupil may see the interdependence of material prosperity and social stability, and learn to look upon contemporary social and economic problems in the light of their historical evolution; one year of elementary algebra and geometry that may open his mind to one of the most useful, the most profound, and to some minds most fascinating systems of thought which man has developed—a result which can never be expected to follow from what the pupil has learned in the narrow field covered by arithmetic; one year of drawing and manual training that will introduce the pupil, on the one hand, to the elements of the fine arts, the decorative arts and the mechanic arts, and on the other, lead him to a just appreciation of the importance of all three in ministering to the æsthetic and the material interests of men, and help him to adjust his own relation to them in thought and deed.*

That is to say, under existing conditions, I mean with the existing unsatisfactory pre-high-school education, still unsatisfactory in spite of the well-nigh universal and decidedly creditable recent attempts to improve it, it seems to me wise to prescribe for every high school pupil at least one year of the language and literature of his mother tongue; one year of American or English history (chiefly political); one year of English and American economic history and civics; or, when possible, one year of elementary political economy, one year of a modern foreign language; one year of science (physical geography, or botany and zoology); one year of algebra and geometry (together); one year of drawing and manual training; each of these subjects with a time allotment of from three to four periods a week.† This prescribed work includes subject matter comprising about one-third of all the work a pupil of ordinary capacity should be required to do during four years of the ordinary high-school program, chosen from each of the great divisions of human culture. It thus affords a reasonably satisfactory basis for the guidance of pupils, teachers and parents, in the choices which they make or advise in harmony with the pupil's real tastes and capacities. It seems to me, therefore, a safe basis for the administration of the elective system in our secondary schools.

---

* Of course, I do not mean to imply that these results can be fully realized in a single year's instruction in the subjects named in this paragraph. I mean that these results are to be aimed at, whatever the duration of the instruction may be.

† I suggest the following time schedule for these studies: English, 3; English, History, or American History, 3; Economic History and Civics, or Political Economy, 3; Modern Language, 4; Physical Geography, or Botany and Zoology, 4; Algebra *and* Geometry, or Algebra or Geometry, 4; Manual Training and Drawing, 4. (The numbers mean so many exercises per week.)

II.

The other problem which I wish to discuss is closely connected with the problem of electives. It is, in effect, how shall we overcome the persistence of the artificial separation of the high school from the rest of the school system—a separation that sometimes almost amounts to isolation? Reference was made above to the unsatisfactory condition of our pre-high-school education in spite of the widespread endeavor to improve it. The grammar school is still emphasizing, too much, a very large remnant of the old formal curriculum. Arithmetic, English grammar and political geography are still looked upon as the solid studies of the later years of the grammar school, as they were before the days of enriched programs. The work in foreign languages, algebra, geometry, history, elementary science, manual training, where any or all of these studies are recognized at all, is still looked upon in most school systems as a new and more or less ornamental addition to the real work of the grammar school.*

In other words, we have not yet taken the newer studies in the grammar school program *seriously*. Hence, as I have already mentioned, most high schools do not regard the work done in these studies in the lower grades as really *done*; and so, in spite of the congested grammar school programme, due to the insertion of the new studies without elimination of the old ones, *root and branch*, from the last years of the grammar school, the high school still assumes—and probably in most cases justly—that everything below the high school is still chiefly a drill in the school arts, just as it used to be; and that such beginnings of a real education as have been attempted in the lower grades are not really beginnings—they are only trifling with high school subjects; and that, consequently, all those subjects must be begun over again. The result is that the separation of the high school from the

* The reluctance of some communities and some teachers to abandon the old-time grammar school studies in the later years of the grammar school program, and to substitute for them the studies that constitute a real education, is largely due to the mistaken belief that the really unpractical and purely technical details of arithmetic and English grammar, and the statistical geography, that still consume so large a share of the pupil's time and attention in the last two or three grammar grades possess more practical utility, and have more educational value than good courses in history, literature, foreign language, elementary algebra and geometry, manual training, sewing and cooking. It should be said, also, that many principals and superintendents doubtless hesitate to adopt the improved program because they have not in their corps a sufficient number of properly equipped teachers—teachers who can be assigned to teach both in a given high school and in the upper grades of one or more grammar schools in its vicinity. But such teachers are not hard to find. Our colleges are sending them forth by the score every year.

lower grades—the 'gap,' as it is often called, between 'the grades' and the high school—still exists, very much as it always has.

This curious break, in what is intended to be a thoroughly unified educational scheme, is such a contradictory phenomenon, in spite of its serious reality, that it would be incomprehensible if it had not followed naturally from the different origins of our elementary and our secondary schools. Our secondary schools originated as (Latin) grammar schools, *i. e.*, as college preparatory schools, designed for a particular social class, and hence possessing no essential articulation with the public elementary schools. The academies, although not class schools to the same extent as the older 'grammar schools,' still concerned themselves little, if at all, with the elementary education of their pupils. When the high schools were founded on the combined model of the 'grammar school' and the academy, these traditions of secondary education were perpetuated—below the high school not a real education, only a preparation for education; education itself was deferred to the high school. Hence, the gap between the high school and the lower grades—the artificial isolation of the high school from the lower grades, which still persists in spite of our recent and contemporary endeavor to bring them together.

Nevertheless, the remedy is really not difficult to apply. We have already made so much progress that the final steps ought not to be difficult to take. We shall take them when we discontinue elementary English grammar as a distinct study, at the end of the sixth grade, and begin there a modern foreign language; when we cut out all the arithmetic in and after the seventh grade, and substitute elementary geometry and algebra; when we similarly cut out most of the political geography in and after the seventh grade, and gradually transform all our nature study during the same time into elementary natural science. When we make these and some other equally important changes *seriously*, and add them to the other improvements already substantially accomplished in our contemporary pre-high-school grades, we shall bridge the gap between elementary and secondary education; and the artificial isolation of the high school in a system of which it is really intended to be an integral part will be outgrown.

I should like to discuss the effect of these suggested changes more at length, but I must content myself here with touching only one of them. It will be noticed that I have spoken of a modern language, not of Latin, as a suitable foreign language for pre-high-school pupils. The reasons for this suggestion are not far to seek. Latin is a difficult language, and when begun at an early age, and without any previous study of a foreign language, is not economically acquired. By economically, I mean the minimum expenditure of time and energy required to make substantial progress in the language. This is be-

coming apparent in the very stronghold of classicism itself—in Germany. It may not be generally known that during the past few years a very interesting experiment has been in progress in Germany; namely, the experiment of cutting off the first three years of the nine years devoted to Latin in the gymnasium and real-gymnasium, and substituting instead three years of French. Three years ago there were in Germany twenty-six gymnasiums and real-gymnasiums, in which this experiment was in progress. Now, I am told, there are no less than forty. The head-masters of these schools were unwilling, in some cases that came under my observation, to express any opinion on the probable results of this experiment until more time had elapsed. The experiments were begun not long after the celebrated conference on secondary education, called by the Emperor in 1890. But others were emphatic in their belief that the experiment would be a success in the interests of Latin itself; and it was really chiefly on this alleged ground that the experiment had been permitted at all. I have no doubt that the results will justify the expectations entertained by its promoters. In this country one of our best known classical schools* has substituted for some years past, for the first year of a six-year course in Latin, a year of French; and there is no disposition whatever to return to the former régime.

A further argument for deferring Latin until after a modern language has been studied could be derived from the analogy of the very successful courses in elementary Greek now established in several American colleges—courses in which at least two years, sometimes three years, of 'preparatory' Greek are done in a single year; and the work is done much better than it can be done in the preparatory school, on account of the greater maturity of the pupils, and their previous linguistic training. All this points to the wisdom of deferring Latin to the later secondary school years *in the interests of the Latin.*

But there is another even stronger reason why a modern language, instead of Latin, should be begun in the grammar school. Of course, I have in mind a *serious* study of the modern language—as serious as if the language were Latin, and with a similar expectation of building on it a superior language training later on. These reasons are, first, that in two or three years a serious study of a modern language will yield a result in general culture infinitely superior to what can be derived from Latin at the same age—*i. e.*, it will give the pupil the power to enjoy and to use another literature besides his own; and especially a literature that he *can* use and enjoy, whether he ever goes to school another day or not; and this cannot be asserted of Latin. I need not remind you that most pupils do not enter the high school; and hence,

* The Roxbury Latin School.

unless they have an opportunity to study a foreign language in the grammar school, they do not get it at all.

Other arguments for such sequence of our language courses as I am pleading for are near at hand; *e. g.*, a pupil's knowledge of, and command over, his mother tongue gains enormously through the study of a foreign language—a modern language is as good for this purpose, for young pupils, as Latin, or even better than Latin; and a modern language in itself may have a commercial value which Latin never has, except, at present, for teachers.

Now, if we had two or three pre-high-school years of a modern language, followed by at least one year—the first high school year—of another modern language *in* the high school, and this followed by three years of Latin and two of Greek for those who care for the ancient languages, who can doubt that our present somewhat meager achievements in the classics in the high school would be greatly increased in quantity and that they would be vastly better in quality? This is the sensible language course of the future for those who study the classics in the high school, as I conceive it, when the high school is completely articulated to the grammar school. When that time comes I think, also, that we shall have precisely inverted the relative emphasis we now place on the classics and on the modern languages in pre-collegiate education for collegiate pupils. We shall follow the pre-high-school modern language courses by substantial high school courses in the languages, and so continue the real education of the pupil begun in the grammar school, instead of deferring it as we now do for the classical student until he reaches the college. For, at present, classical education in the secondary school, like the formal education that used to precede it in the elementary school, is, for most pupils, only an alleged preparation for education, not education itself.

When we articulate our pre-high-school courses in history, science, mathematics, manual training, and the rest, with the corresponding high school course, in some such way as has just been suggested for foreign language courses, we shall then make the pupil's school career a *real* and not a deferred education at every stage of his progress; and the historical disparity between the *kind* of studies pursued below the high school and those pursued in the high school will disappear. There will be no artificial separation of the high school from the rest of the school system. We shall have adjusted our educational endeavor to the real process of the pupil's unfolding development, and shall really make our schools minister equally to all classes of pupils, whether they have the good fortune to be born of wealthy and socially superior parents, or whether merely equipped with ability and earnestness, they are obliged to make the most of the brief educational career their circumstances will permit.

A STUDY OF BRITISH GENIUS.

By HAVELOCK ELLIS.

IV. HEREDITY AND PARENTAGE.

THE heredity of intellectual genius has been very fully discussed, with special reference to eminent persons of British birth, by Mr. Francis Galton.* With, perhaps, even an excess of zeal—for persons of somewhat minor degrees of ability have sometimes been taken into account—Mr. Galton has shown that intellectual ability has frequently tended to run in families. If this hereditary tendency is by no means omnipresent, the present data prove conclusively that it is a very real factor. Notwithstanding that the effects of hereditary position have been so far as possible excluded, and that our lists only include persons of preeminent ability, distributed over fifteen centuries, it is yet found that among these 902 persons there are 31 groups, of two or three individuals in each group, who are closely related. These groups include 65 persons in all. The recognized relationships are father and son, brother and brother, brother and sister, sister and sister, uncle and nephew, aunt and nephew, uncle and niece, grandfather and grandson. Cousinship and more remote relationships also occur, but have not been included.† In nineteen of these groups the ability shown may be said to be of a similar kind; in twelve it may be said to be of different kinds. There are only three cases in which the group consists of three persons: the Bacons, the Kembles, the Wordsworths. It is scarcely necessary to remark that in a very large number of cases the preeminent persons in our list were nearly related to other eminent persons who have not reached the degree of distinction entitling them to appear in the list. Of these no note has been taken.

I have, however, noted every case in which it is stated or implied that one or other, or both, of the parents possessed an unusual amount of intellectual ability, by no means necessarily involving any degree whatever of 'eminence.' These cases are very numerous, and as such ability may often have been displayed in very unobtrusive ways, it must frequently have escaped the attention of the national biographers. In

*See especially his 'Hereditary Genius.'

† It is quite possible, however, that such remote relationships are not without significance. One cannot but be struck by such a fact as the relationship of Shelley through his mother with the lyric poet Southwell, with whom he has so real an emotional affinity.

123 cases the father showed such ability; in 65 cases the mother is noted as of unusual ability, or else as being closely related to some person of eminent ability; in 20 of the 65 cases the mother was closely related to some person of very eminent ability, and may, therefore, be fairly presumed to have transmitted an intellectual aptitude whether or not she showed marked signs of such aptitude herself. In 14 cases both the father and the mother probably transmitted intellectual aptitudes. Making allowances for this, it may be said that at least 181 men and women of distinguished ability, or about 20 per cent. of our 902 eminent persons, have inherited intellectual aptitudes. Bearing in mind that in many cases the aptitudes of the parents are unknown or have passed unnoticed, and that in other cases the national biographers have failed to record known facts, it is not improbable that the proportion of cases in which one or other of the parents of our 902 eminent persons displayed more than average intellectual ability may be at least doubled.

If we consider the eminent women separately we find that, while 8 have had fathers of unusual intellectual ability, only 2 have had mothers from whom it can be said that they probably inherited. In one further case (Fanny Burney) both parents possessed ability, the father, however, in a more eminent degree than the mother. Moreover, the two cases in which the mother may probably be said to have transmitted the ability (Mrs. Siddons and Joanna Baillie) are more dubious than those in which it was transmitted by the father. So far as the present very limited data go, it seems probable, therefore, that women have a still more marked tendency than men to inherit intellectual aptitudes from their fathers.

It would be interesting to inquire into the moral and emotional qualities, the 'character,' of the parents. This, however, is extremely difficult and I have not attempted it. If we could do so we might find that the mothers of eminent men have had greater influence on their sons than the facts, so far as it has been possible to ascertain them, regarding the transmission of purely intellectual aptitudes would lead us to believe. In a great many cases the mother was a woman of marked piety, and we are frequently led to infer an unusual degree of character on the part of the mother, if not of the father. Moral qualities are quite as essential to most kinds of genius as intellectual qualities, and they are, perhaps, even more highly transmissible. They form the basis on which intellectual development may take place, and they may be transmitted by a parent in whom such development has never occurred. The very frequent cases in which men of eminent intellectual ability have declared that they owed everything to their mothers* have some-

*A remark of Huxley's in a letter to the present writer—"Mentally and physically I am a piece of my mother"—may be taken as typical of such declarations.

times been put aside as the expressions of an amiable weakness. It requires some credulity, however, to believe that men of preeminent, or even less than preeminent, intellectual acuteness are unable to estimate the character of their own parents. The frequent sense of indebtedness to their mothers expressed by eminent men may be taken as largely due to the feeling that the inheritance of moral or temperamental qualities is an even more massive and important inheritance than definite intellectual aptitudes. Such inheritance coming to intellectual men from their mothers may often be observed where no definite intellectual aptitudes have been transmitted. It is not, however, of a kind which can well be recorded in biographical dictionaries, and I have not, therefore, attempted to estimate its frequency in the group of preeminent persons under consideration.

I have, however, attempted to estimate the frequency of one other form of anomaly in the parents besides intellectual ability. The parents of persons of eminent intellectual power may not themselves have been characterized by unusual intellect; but they may have shown mental anomaly by a lack of aptitude for the ordinary social life in which they were placed. In at least 31 cases (or over 3 per cent.) we find that the father was idle, drunken, brutal, extravagant, unsuccessful in business, shiftless, or otherwise a ne'er-do-weel. In such cases, we may conclude, the father has transmitted to his eminent child an inaptness to follow the beaten tracks of life, but he has not transmitted any accompanying aptitude to make new individual tracks. This list could easily be enlarged if we included milder degrees of ineffectiveness, such as marked the father of Dickens (supposed to be represented in Micawber). A certain degree of inoffensive eccentricity, recalling Parson Adams, seems to be not very uncommon among the fathers of men of eminent ability, and perhaps furnishes a transmissible temperament on which genius may develop. It may be noted that 5 of the ne'er-do-weel fathers (a very large proportion) belonged to eminent women. Whether this confirms the conclusion already suggested as to the special frequency of paternal transmission in the case of women of eminent ability I cannot undertake to say. It may be added, however, that a ne'er-do-weel father, by forcing the daughter to leave home or to provide for the family, furnishes a special stimulus to her latent ability.

In 276 cases I have been able to ascertain with a fair degree of certainty the size of the families to which these persons of eminent ability belong. A more than fair degree of certainty has not been attainable, owing to the loose and inexact way in which the national biographers frequently state the matter. Sometimes we are only told that the subject of the article is 'the child' or 'the son'; this may mean the *only* child, but it is impossible to accept such a statement as evidence regarding the size of the family, and the number of families with only children

may possibly thus have been unduly diminished. Again, the biographers in a very large number of cases ignore the daughters, and from this cause again their statements become valueless. In estimating the natality of the families producing children of ability I have never knowingly reckoned the offspring of previous or subsequent marriages; so far as possible, we are only concerned with the fecundity of the two parents of the eminent persons. So far as possible, also, I have reckoned the gross fecundity, *i. e.*, the number of children born, not the number of children surviving; in the case of a large number of eminent men this gross fertility is known from the inspection of parish registers; in a certain proportion of cases it is probable, however, that we are only dealing with the surviving children. On the whole, the ascertainable size of the family may almost certainly be said to be under the mark. It is, therefore, the more remarkable that the average size of genius-producing families is found to be larger than that of normal families. The average of the normal English family is at the very most 6;* the average size of our genius-producing families is 7 (more exactly, 6.96). In order to effect an exact comparison I have looked about for some fairly comparable series of figures, and am satisfied that I have found it in the results of an inquiry by Mr. F. Howard Collins concerning 4,390 families.† These families furnish an excellent normal standard for comparison; they deal mainly with 'Anglo-Saxon' people (in England and America) of the middle and upper classes; they represent, with probably but very slight errors of record, gross fertility; they are apparently not too recent, and they betray little evidence of the artificial limitation of families. The mean size of Collins's group of fertile families is found by Pearson to be 4.52 children. Comparing in more detail the composition of our genius-producing families with the normal average, we obtain the following results:

Size of family.....	1	2	3	4	5	6	7	8
Normal families.....	12.2	14.7	15.3	14.1	11.1	8.6	7.8	6.3
Genius-producing families .	6.2	6.2	11.0	8.4	10.6	10.2	11.7	6.9

Size of family.....	9	10	11	12	13	14	over 14
Normal families.....	3.9	2.7	1.4	1.0	.5	.2	.1
Genius-producing families..	5.5	4.4	5.8	4.0	2.9	1.8	4.0

Unless, as is scarcely probable, the mental eccentricities of biographers lead to very frequent selection on definite lines, it will be seen that there is a very marked tendency for genius-producing families to

* This was the average fertility of 1,700 marriages, as ascertained by Ansell, Duncan, 'Sterility in Women,' p. 4. Galton found the mean of 204 marriages 4.65, and Pearson the mean of 378 fertile marriages 4.70.

†As quoted by Karl Pearson, 'The Chances of Death,' Vol. I., p. 70. In passing through Mr. Pearson's mathematical hands the 4,390 emerge as 4,444, and it is on this number that my percentages for normal families are based.

be abnormally large.* In genius-producing families there is an invariable deficiency of families below the average normal size, and an invariable excess of families above that size. In the largest size group (over 14) the excess becomes extravagantly large; this, however, may be partly accounted for; we may be sure that the biographers have seldom failed to record families of this size, so this group has really been recruited from the families of all our 902 eminent persons. Even on this basis, however, it remains extremely large; in Denmark, for instance, it is stated, a family of 22 children only occurs once in 34,000 marriages.†

If, as seems probable, it may be asserted that genius-producing families are characterized by a tendency to an abnormally high birth-rate, this is not a fact to cause surprise. It might, indeed, have been anticipated. The mentally abnormal classes generally belong to families with a high birth-rate. This has been shown by Ball and Régis (confirmed by Marandon de Montyel) to be markedly the case as regards the insane. Magri has found it to be the case as regards criminals, as well as regards the epileptic, hysterical and neurasthenic.

An interesting point, and one which can scarcely be affected at all by any twist in the biographical mind, is the fact that our men of ability (the women are here excluded) are the offspring of predominantly boy-producing parents. Taking the 64 families in which the number of boys and girls in the family is clearly stated, and excluding 12 of these as consisting only of boys, we find that there are about 6 boys to 5 girls, or more exactly, 111 boys to 100 girls. The normal proportion of the sexes at birth at the present time in England is about 104 boys to 100 girls. It is in accordance with the predominantly boy-producing tendency of families yielding men of genius that the families yielding women of genius should show a predominantly girl-producing tendency. Here, indeed, our cases are far too few to prove much, but the results are definite enough so far as they go. Putting aside the families consisting only of girls, the sexual ratio is rather more than 3 boys to 4 girls, or more exactly, in the ratio of 85 boys to 100 girls. Putting the matter in another way, we may say that, while in every ten families from which men of genius spring, the boys pre-

*This tendency has already been noted by Galton when investigating English men of science, and by Yoder in studying a small miscellaneous group of eminent men.

†In our genius-producing group there are 4 families of more than 19 children. Doddridge was the youngest of 20 children; Popham was the youngest of his mother's 21 children; Colet was the eldest and only surviving child of 22; Dempster was, or stated himself to be, the 24th, of 29 children. There was a strong tinge of romance about Dempster, and I fear that we cannot accept this statement with such complete confidence as would be desirable.

dominate in six families, in ten families from which women of genius spring the boys predominate only in three.

I have made a tentative effort to ascertain what position in the family the child of genius is most likely to occupy. In a large number of cases we are only told his position as a son, not as a child; these are, of course, excluded. In order to investigate this point I considered the families of at least 8 children (and subsequently those of at least 7 children) and noted where the genius child came. This showed a very abnormally large proportion of eminent first children, and also abnormally few second and third children. Suspecting that certain peculiarities of the biographical mind (needless to enter into here, since we are not investigating the psychology of biographers) may have somewhat affected this result, I have confined myself to a simple inquiry less likely to be affected by any mental tendencies of the biographers. In families of different sizes, what relation do eldest genius children and youngest genius children bear to genius children of intermediate position? The results are very decisive. If, for instance, we take families of 7 children, it is found that they yield 8 eldest children of ability and 3 youngest, but only 10 for all the intermediate positions. If we take 8-children families, there are 3 eldest children of ability and 3 youngest, but only 10 intermediate. Again, 9-children families show as many as 4 eldest children of ability and 4 youngest, but only 1 intermediate child. So with 10-children families, there are 3 eldest children of ability and 3 youngest, but only 3 for all intermediate positions. It is so with families of 11 children and of 13 children. The only exception I have detected is in the case of 12-children families, in which group youngest children are wanting. So marked is the preponderance of eldest and youngest children of ability that only in two of these seven groups (7-children families to 13-children families) do the intermediate children of ability exceed in number the eldest and youngest children combined. It is evident that there is a special liability for eldest and youngest children to be born with intellectual aptitudes, the liability being greater in the case of the former than of the latter, for there are in the seven groups 24 eldest children to 18 youngest children, the intermediate children numbering 40.

Here again the results, however remarkable they may appear, are strictly such as we might have been led to expect. In the other mentally abnormal classes we find exactly similar phenomena. Thus, among 433 idiots Mitchell found that 138 were first-born children and 89 last-born children; so that here not only were the eldest and youngest children in an absolute majority over all those of intermediate position, but the eldest had to the youngest almost the same ratio (4 to 3) as we have found in the genius group. Shuttleworth has lately stated that among the so-called 'Mongolian' variety of imbeciles quite 40 per cent.

are the youngest members of large families. Bohannon found that youngest children tend to be exceptional and abnormal, precocity being a specially prominent trait among them. Among the socially degenerate classes Dugdale found first-born and last-born prominent, the former tending to be criminals, the latter paupers.

Whenever it has been possible I have noted the age of the father at the birth of his eminent child. It has been possible to ascertain this in 204 cases, and the data thus obtained may be considered as fairly free from fallacy, so far as the biographical mind is concerned. The range of age is considerable, from 15, the age of Napier of Merchiston's father at his birth, to 79, the age of Charles Leslie's father, the period of potency in the case of the fathers of persons of eminent ability thus ranging over 64 years. The 204 cases may be grouped in five-year age-periods as follows:

Under 20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60 and over
1	7	22	54	41	33	24	9	7	6

These figures run in a fairly smooth and regular way, and I believe that they are very noteworthy and significant. It will be seen that 30-34 is the most frequent age of fatherhood, and that while there are very few cases of fatherhood during the ten preceding years, when sexual vigor is at its height, the majority of eminent persons have been begotten by fathers who had already passed this age of most frequent fatherhood. This result is the more significant when we remember that we are chiefly dealing with the upper social classes (for it is in their cases that these facts are most easily ascertained), and that we must exclude the quite modern tendency to retardation of the age of marriage. I have no figures of the age of fatherhood among normal subjects quite fairly comparable with those here presented. The significance of the age of fatherhood has been chiefly studied, so far as I am aware, by Marro in North Italy, and we cannot assume that the conditions are there quite the same. Marro divided the fathers of his normal subjects into three classes: (1) Below 25 years of age, a stage of immaturity; (2) from 26 to 40 years of age, a stage of maturity; (3) over 40 years of age, a stage of decadence. He found that 8.8 per cent. fathers of normal subjects belonged to the first group, 66.1 to the second class and 24 to the third. The corresponding figures for the fathers of the persons of eminent ability concerned in the present inquiry are 3.9, 57.3 and 38.7. Whatever the value of this comparison, there can be little doubt that an abnormally high age prevails among the fathers of our eminent persons. I have only been able to ascertain the age of the mother in 40 instances. In these cases it is distributed as follows:

Age of mother.....	21-24	25-29	30-34	35-39	40-44	45-49	50
Number of cases.....	8	13	8	5	4	1	1

Except for the one very unusual instance at 50 (Dibdin's mother),

this distribution seems to indicate that the mothers of persons of intellectual ability are predominantly at the period of greatest vigor and complete sexual maturity when they produce their distinguished children. Notwithstanding the tendency of first-born children to show intellectual ability, none of the mothers are under 21.

It may be noted that in at least 36 of the 276 cases in which we have details of the family history (or in about 13 per cent.) the mother was a second or third wife. In at least 6 cases the father was a second husband.

It would have been instructive to compare the ages of the parents and to ascertain the degree of disparity. I have only been able to do this in 34 cases. There is a marked tendency to disparity which ranges up to 49 years.* Whatever may be the normal amount of disparity between the ages of parents, it certainly tends to range chiefly below 4 years, but in this group only 8 cases (*i. e.*, in the proportion of about 23 per cent.) show less disparity than 4 years; the majority range between 4 and 8 years, and as many as 8 (*i. e.*, in the proportion of over 22 per cent.) show a greater disparity than 10 years.† In 6 out of the 34 cases the mother was older than the father. In a considerable proportion of cases both parents were elderly.

On the whole it would appear, so far as the evidence goes, that the fathers of our eminent persons have been predominantly middle-aged and to a marked extent elderly at the time of the distinguished child's birth; while the mothers have been predominantly at the period of greatest vigor and maturity, and to a somewhat unusual extent elderly. There has certainly been a notable deficiency of young fathers, and, still more notably, of young mothers.

Our data at this point are too few to be very decisive, but, so far as they indicate anything, they enable us once again to bring men of 'genius' into line with the other mentally abnormal classes. The late Dr. Langdon Down (who at my suggestion investigated the point some twelve years ago) found that in the case of the parents of idiots there was a disparity of more than ten years in 23 per cent. cases, almost the same proportion as we have found in the parents of persons of intellectual ability. Among criminals also inequality of age in the parents, as well as elderly age of both parents, has been found by Marro to be more common than among the normal population. Marro (in his 'Carat-

*This very exceptional case was that of the father (an eminent bishop) of Charles Leslie, the nonjuring divine. In this case the father was 79, the mother 30.

†In Hungary, as a table given by Körösi shows, if we take men at ages between 26 and 30, covering the most frequent normal age of marriage, in only 3 per cent. cases is the discrepancy of age as much as ten years. The disparity, of course, tends to increase with the man's higher age at marriage.

teri dei Delinquenti' and 'La Pubertà') has investigated the whole question of the influence of the age of the parent on the character of the child. He has found that when both parents are in the same period of age development elderly parents produce the highest proportion of 'very intelligent' children (though not the highest proportion of 'intelligent' children). Marro has also found that, taking the fathers alone, although 'intelligent' children are mostly the offspring of young fathers, 'very intelligent' children are mostly the offspring of middle-aged and elderly fathers. He finds much the same result as regards mothers. He found that the insane show an excess of elderly fathers, while murderers show a deficiency of young fathers and a very great excess of elderly fathers. The highest proportion of defectively intelligent children (this harmonizing with Langdon Down's results) Marro also found among the offspring of elderly fathers. Elderly fathers and very young mothers were found by Marro to produce the largest proportion of 'good conduct' children, but not of intelligent children.

SUICIDE AND THE WEATHER.

By Professor EDWIN G. DEXTER,
UNIVERSITY OF ILLINOIS.

MUCH has been written and rewritten on the subject of suicide. It has long been a favorite topic with the student of social statistics, and has been scientifically treated from the standpoint of race, of nationality, of social condition, of occupation and of climate. Whole volumes have been devoted to the problem and magazine articles almost without number. It is not, however, my intention in this paper even to summarize the conclusions arrived at in all this mass of literature, but to discuss a phase of the subject which can not have escaped the reader of the daily paper, and has long proved an enigma to the special student of the problem of self-destruction—that is, the daily fluctuation in the occurrence of suicide. Why is it that upon picking up our daily paper one morning we see the heading 'Epidemic of Suicide', and find the details of six or eight or even a dozen successful or unsuccessful attempts recorded for the previous day—a number greater than for the whole week preceding? Yet such is often the case—so often, in fact, as not infrequently to have been the subject of editorial comment, with vague queries as to the cause of such a wave of emotional depression and consequent self-destruction.

The answers to this query have been many and varied, among the most frequent of which has been chance. Mimicry and suggestion have been proposed, and without doubt have their place in the solution of the problem of the periodical fluctuation of the suicide curve, but still can not account for all its peculiarities. The weather has also been suggested as the cause of the fluctuation referred to, and it is to the following out of this promising clew that this paper is confined.

From *a priori* grounds it would seem to be a good one, for of all the environmental conditions, those of the weather are the only ones which vary for all the individuals in a given locality simultaneously. A and B and C all have troubles peculiarly their own, the climax of which could not be expected to occur upon the same day; but when the east wind blows and the sky is leaden A, B and C all feel the influence, whatever it may be, and an empirical study of large numbers of A's and B's and C's, noting their behavior under such conditions, would seem to be the surest method of discovering just what the influence is.

That weather states have a mental effect has long been recognized. Literature is full of allusions to the fact, and not a few of the world's

great thinkers have left on record their own emotional flights and depressions under different meteorological conditions. But most of us need to take no other word for the fact than our own. In all the vigor of perfect health such influence may hardly be recognized, but when the vital powers are depleted by the exhausting effects of a long nervous or physical strain, then this phase of the cosmical environment is sure to make itself felt. Then come the days when everything goes wrong. The groundwork of forgotten quarrels is remembered, uneasy questions arise with regard to the future; one gets tired of life. And how much of all this can be attributed to an east wind or a leaden sky—in other words, to weather effects? In order to answer this question we must define our use of the term 'weather effects.' From the standpoint of our present study we should include within the category of weather effects any marked inequality in the occurrence of suicide which may be found to bear a fixed relation to the fluctuations of what we call weather. We conclude that a fixed relation between a given weather state and an unusual prevalence of suicide is causal and not accidental. This is based upon an inductive study of large numbers of data, and is as valid as such studies can well be.

The problem, then, consists in discovering these fixed relations. In order to do this with exactness, the meteorologist's analysis of weather must be taken. To him a given weather state is a complex and not a simple phenomenon. He reads its temperature, its barometer, its humidity, its wind velocity, its sunshine or shade, and its precipitation, and it is only to the synthesis of these conditions that he applies the term weather. For the purpose of our present study it is not enough to say that the weather is fine, or disagreeable, or muggy, for those terms mean one thing to one person and something very different to another, so it has been necessary to make use of a definite meteorological nomenclature which is recognized the world over. The study is in no sense an attempt to account for suicide, but for the irregularity of its occurrence. Man always has sought and perhaps always will seek self-destruction as the relief for sorrow, fancied or real, and the basal reason for this is not to be found in the weather. We would not argue that the weather drives people to suicide save in very exceptional cases, but, on the strength of what follows, that under some weather states other things are peculiarly liable to drive people to the act. In other words, that some meteorological conditions so affect the mental state, so influence the emotional balance, that ordinarily endurable things become unendurable, and life seems no longer worth the living.

This problem, which seems to show a causal nexus between the weather and the mental state of the suicide, is a comparison of the occurrence of suicide under different meteorological conditions, with the normal prevalence of those conditions, noting the excess or deficiency.

The data were collected for New York City and the city of Denver, Col., and although the climatic conditions of the two cities are very different, it is in no sense a comparative study for them. In fact, so few data (two hundred and sixty suicides) were procurable for the western town that but little weight is given to conclusions based upon them, compared with the much greater number for New York City, and the study of the former is only incidentally mentioned.

The method of procedure was as follows: In order to procure the proper data of suicide for the city of New York the records of the coroner for five years were carefully gone over (some 28,000 separate death certificates), disclosing the particulars of 1,962 suicides, and the exact number (varying from 0 to 9) tabulated for each of the 1,826 days of those years. Next the police records for the same five years were studied, and the number of unsuccessful attempts for each day noted. This record is quite complete, since in the eyes of the law one attempting suicide is a criminal, and must be so branded on the books. From these two sources were obtained the exact number of persons who for each day of the period covered were of suicidal intent, unless some unsuccessful attempt escaped the surveillance of the police. In the present article neither age, sex, nationality, nor occupation is considered; simply the fact that some one wished to die by his own hand—for the five years, 2,946 in all for the city of New York.

When the data of suicide had thus been tabulated, the meteorological basis for the study was obtained from the records of the United States Weather Bureau. At the New York station (Denver for the Denver study) were copied the mean temperature, barometer and humidity, the total movement of the wind, the character of the day and the precipitation for each of the 1,826 days of the period considered, and placed opposite the already tabulated number of suicides. Then, by a somewhat laborious process of tabulation, the exact percentage of days which were recorded at the Weather Bureau under each of the seventy-seven definite meteorological conditions represented by the accompanying figures was computed. That is, the exact percentage characterized as 'clear,' as 'partly cloudy,' or 'cloudy,' as having some or no precipitation (without considering the amount), as having had a mean temperature between zero and five degrees F., between five and ten degrees, and so on for each one of the designated groups for temperature, barometer, humidity and wind. Now, it may be readily seen that these percentages represent the normal or expected occurrence of suicide for each meteorological group *if the weather had no effect.* For instance, if thirty per cent. of the days are found to be characterized as 'clear,' we should expect that same percentage of suicides for 'clear' days plus or minus the percentage due to probable error from accidental causes (which with the number of data used would be very small) *if the character of the day had no influence on*

their occurrence. If forty per cent. did actually occur under such conditions, we should be forced to conclude that fair days were prolific of suicide, as indeed they seem to be. This principle was applied to each of the meteorological groups, and the figures show graphically the results.

For each, the general meteorological condition is indicated at the top; the definite group readings are given in small figures upon the heavy vertical lines which represent the occurrence of suicide for the group. Expectancy for each group is represented by the vertical distance A—B and excess or deficiency graphically shown in percentages of this, which may be read by means of the scale at the left.

The method of tabulation, by means of which the actual occurrence of suicide for each meteorological group, was determined was similar to that for expectancy, and needs no further explanation.

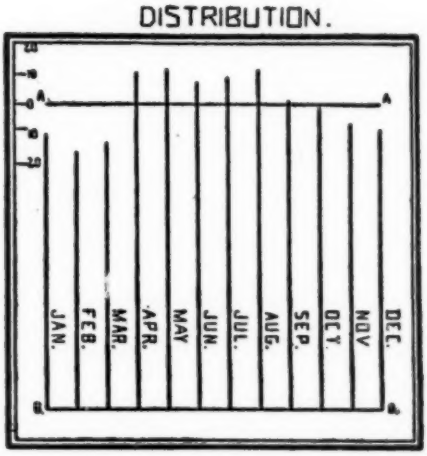


FIG. 1.

MONTHLY DISTRIBUTION.—Fig. 1 indicates very wide variation in the number of suicides occurring in the different months of the year—generally speaking, the heated months showing excesses and the cold ones deficiencies when compared with the normal. May and August show the greatest numbers, with the least for February, in spite of the fact that the shortness of the last-named month is taken into consideration.

It may be seen, by an inspection of the figure, that the increase in number for each month from February to August, and the decrease for the other months of the year, would give an almost perfectly regular *crescendo-diminuendo* to the occurrence curve were it not for the fact that April and May are raised out of their position by unusual excesses. Why April, which in its general weather characteristics is Elysian compared with its immediate predecessor, should show one-fourth more sui-

cides, and May, which by common acclaim is one of the most delightful of the calendar, should present a number surpassed only by sweltering August, it is not easy to see. Yet such is the case for the five years covered by this study, and similar conditions have been demonstrated by other students of the subject. Morselli, in his exhaustive treatise for the European nations, finds that for thirty-two separate studies made by him the maximum numbers were in June eighteen times and in May eight times. In explanation of the fact he says, "Suicide is not influenced so much by the extreme heat of the advanced summer season as by the early spring and summer, which seize upon the organism not yet acclimatized and still under the influence of the cold season." There is little doubt that the end of winter brings with it a depleted condition of vitality, both nervous and physical; yet I am inclined to think that the

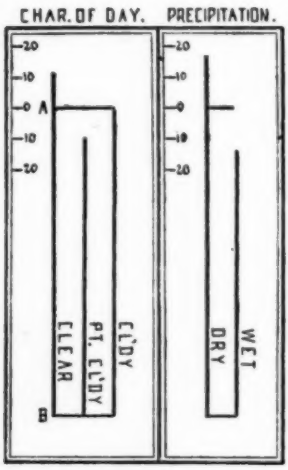


FIG. 2.

fact can not wholly account for the great increase in the later spring months. In the conclusion of this paper the condition is again alluded to, and at this point I would simply call attention to the fact that the increase comes with the season of the year when rejuvenating Nature is in her brightest mood.

CHARACTER OF THE DAY AND PRECIPITATION.—The terms 'clear,' 'partly cloudy' and 'cloudy,' as used by the Weather Bureau's characterization of weather states, have a definite and technical meaning. The first is used to designate days on which the sun is obscured for three-tenths or less of the hours from sunrise to sunset; the second from four-tenths to seven-tenths of that period; and the third eight-tenths or more. (See Fig. 2.)

Under precipitation I have considered separately days which were

absolutely free from rainfall or snowfall, and those on which there was either, without considering the amount.

The figure referred to discloses some unexpected facts—namely, that the clear, dry days show the greatest number of suicides, and the wet, partly cloudy days—the gloomiest of all weather—the least, and with differences too great to be attributed to accident or chance; in fact, thirty-one per cent. more on dry than on wet days, and twenty-one per cent. more on clear days than partly cloudy. As will be seen, on cloudy days the occurrence was about normal. What does this mean? Must fiction resign her right to ring in gloomy weather and blinding storms as a partial excuse for ending an existence made more unendurable by these? If such be the case, it is well that Dickens and Lytton and Poe are gone, for they would be robbed of a large number of their tragic climaxes. England has long been characterized as 'gloomy Britain,' and Montesquieu has called it the 'classic land of suicide,' stating that the 'excessive number of suicides for that country is due to its gloomy weather.' Statistics have shown, however, that the number is not excessive there, being less per million inhabitants than for any other important European nation. An interesting paper, appearing in the British magazine *Once a Week* (vol. xix.) over no signature (though the writer was evidently not a Scotchman), has a bearing upon the subject. It says:

"The idea that the prevalence of suicide in this country (England) is due to our bad weather is precisely one of those hasty and illogical inferences which are characteristic of the Gallic mind. The constant gloom of bad weather ought to acquaint us so thoroughly with moods of depression that suicide would never occur to us. Look at Scotland, for instance, where suicides are rare. Why are they rare? Simply because a succession of Scotch Sundays has so accustomed the people to prolonged despondency that any sudden misfortune can not sink their spirits any further. One has only to spend a dozen Sundays in Glasgow or Edinburgh to become inoculated against suicide. So far from London fogs driving people to jump off Waterloo Bridge, they ought to train the mind to bear any calamity. A man who has taught himself to eat prodigious quantities of opium feels scarcely any effect from other forms of intoxication. We can educate our mental susceptibilities as we can our muscles, and the more we educate them the more they are able to bear."

There are many truths beneath the jocular vein of this quotation, and the writer expressed more facts than perhaps he knew.

Certainly a comparison of suicides for Denver and New York City supports his theory, for in the former city, where cloudy and partly cloudy days are less than one-third as frequent as in the latter, we find suicide excessive during the gloomy weather. Yet the conditions there, both social and climatic, are so unusual as to give this fact little weight in a comprehensive study of suicides, and we must maintain that Vilemais's dictum that 'nine-tenths of the suicides occur in rainy or cloudy

weather' is utterly unfounded upon fact, at least for the conditions covered by this study.

TEMPERATURE.—Fig. 3 seems to show plainly two things: (1) That the greatest excesses of suicide are found at the two extremes of the temperature scale, when the conditions entailed the maximum of actual misery, and (2) that the next greatest excesses occur during the pleasantest conditions of temperature. I would here, however, call attention to the fact that for all the figures the readings at the extremes of the conditions are based upon fewer data than those nearer the middle, hence are more liable to accidental error. For example, although the temperature group zero to five degrees shows an excess of two hundred and

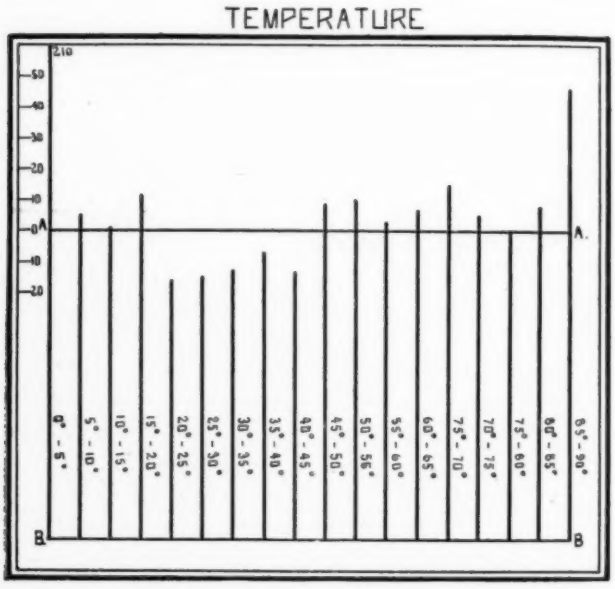


FIG. 3.

ten per cent., the condition occurred but twice in the five years studied, and the whole number of suicides was but eight, while the excess of fifteen per cent. for the group sixty-five to seventy degrees is based upon two hundred and sixty-eight. For this reason the value of the readings at the extremes of all the figures, except Fig. 1 and the upper limit of Fig. 5, at which point there were data enough to give validity to the findings, is lessened when compared with other points in the curves.

Taking this fact into consideration, the greatest numerical excesses in suicide occur in the temperature group from forty-five to seventy degrees. This places them within the category of most agreeable temperatures, for within those limits are found the monthly means of April, May, June, September and October. The deficiencies of suicide occur

in the groups from twenty to forty-five degrees, conditions which are not generally considered most agreeable and within which are found the monthly means for the colder months of the year.

These results, however, are corroborative of the findings for the study of monthly occurrence which show deficiencies for those months. The excesses for extreme conditions of heat and cold are perhaps only what might be expected. In the thickly populated tenements of the city great heat becomes so oppressive as hardly to be endured, and at the other extreme of temperature, when the mercury of the ther-

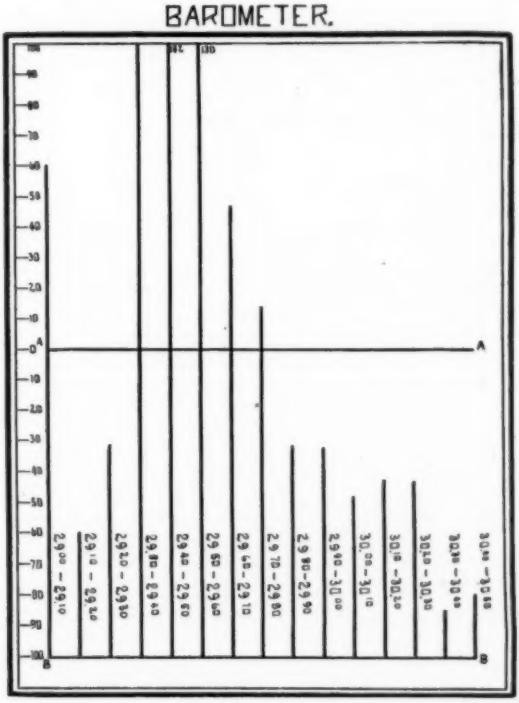


FIG. 4.

mometer is only in the bulb, both personal misery and a feeling of sympathy for a dependent family might prompt one to self-destruction as the last resource.

This curve does not differ materially from that of the Assault and Battery,* except that in the latter it is shown that for the highest temperature ever experienced those misdemeanors, as recorded by the police, show deficiencies. For them the numbers increase regularly up

* See 'Conduct and the Weather,' Monograph Supplement No. 10, 'The Psychological Review.'

to a temperature of eighty-five degrees, but above that point they fall off very rapidly. This fact, however, is not hard to account for, since a considerable amount of energy is required to be objectionably out of order, and at such conditions of heat this seems hardly available.

BAROMETER.—Considering the liability that accidental conditions affect the validity of our curves at their extremes, the results shown in Fig. 4 prove conclusively that low conditions of pressure are accompanied by excesses in suicides, with corresponding deficiencies for the reverse barometrical readings. We can not, however, suppose that it is the actual density of the atmosphere which produces this marked effect. A difference of pressure as great as that between the two extremes for New York City would be experienced in going to the Adirondacks, and five times as great in a trip to Colorado, without producing tendencies to personal annihilation, so we must look for our explanation elsewhere. It is probably to be found in the relation which exists between atmospheric pressure and some other weather states—possibly storms. The peculiar mental and physiological conditions which prevail for a considerable period just preceding violent storms or marked changes of weather have long been recognized, and it may be that in them we have the solution. Persons afflicted with gout or rheumatism, or even corns, can 'feel' the approach of such meteorological conditions, and certain mental peculiarities are probably just as prevalent. Many weather proverbs are based upon the unusual activities of members of the animal kingdom at such times, and as a storm is often preceded by a low condition of the barometer, we have perhaps an explanation of their cause. More work, however, must be done to demonstrate this as a scientific fact.

HUMIDITY.—The results of the study of suicide for this condition (Fig. 5) are in themselves conclusive, but directly opposite to those found in similar studies made for Assault and Battery, Deportment in the Public Schools and the New York City Penitentiary, and the behavior of the insane.* For suicide the excesses are for high humidities; for the others mentioned they were for low.

The showing for suicides seems to be what would be naturally expected if we were to theorize on the matter, as those unendurable 'sticky' days, when one feels it his prerogative to be 'out of sorts,' are usually of high humidity. There are some interesting conclusions to be drawn here by a comparison of this curve with that for precipitation. The latter showed deficiencies of suicide for rainy days, while this gives an excess for humid ones. Now, all rainy days are humid, but not all humid days are rainy, and our logical conclusion must be that the excesses shown by the present figure must have been for the humid variety, yet

* See 'Conduct and the Weather.'

without precipitation. Such precisely is the 'sticky' weather mentioned, and its effect must have been deadly to produce such results.

In accounting for the unusual number of assaults and misdemeanors in the public schools for low humidities, as discussed in the paper cited, the electrical potential of the atmosphere for such meteorological conditions was considered the cause. It is a fact conceded by scientists that at every point upon the earth's surface there are lines of electrical force extending off into space, and that the potential is roughly in a reverse ratio to the humidity prevailing at a given time. This electrical condition for regions of universally low humidity, as the altitudes of our western plateaus, is very marked and productive of no slight effects. These

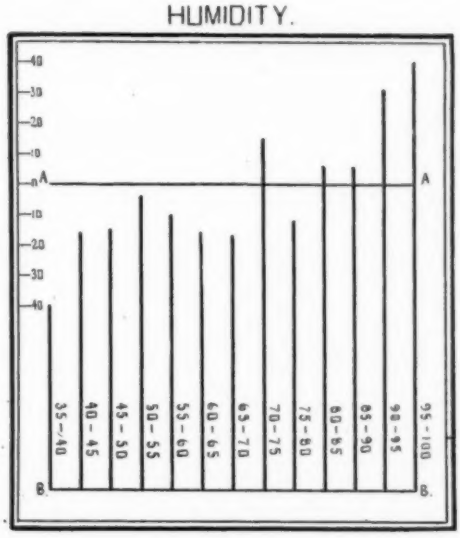


FIG. 5.

seem to be a mental and even physical exhilaration, productive of energy which in the long-run generally proves to be in excess of the normal healthy possibilities. The result is for those regions a tendency to overwork, especially mentally, with a resulting state of collapse. Although these conditions are not so marked for the higher humidities of the sea-level, they nevertheless exist to a degree, and without doubt in New York City there is less individual surplus energy when the humidity is relatively high than when relatively low. This would lead us to infer that, from the showing of this condition, suicide was excessive when energy was low. This relation of occurrence to available energy is reversed for certain of the figures, but other conditions enter in which are discussed in the conclusion of this paper.

WIND.—But little need be said upon the effect of this factor as shown by Fig. 6. The regularity of the increase of suicide with increase in movement of the wind is too marked to allow any other theory than that of a causal nexus. This effect seems to be much greater upon the suicide than upon any of the offenders mentioned in the study cited. It is, however, shown to be as great or even greater for all classes of crime in the Colorado climate, where wind is an important factor in the production of high electrical states. The other study, however, showed very slight wind effects for New York City, and their comparison with

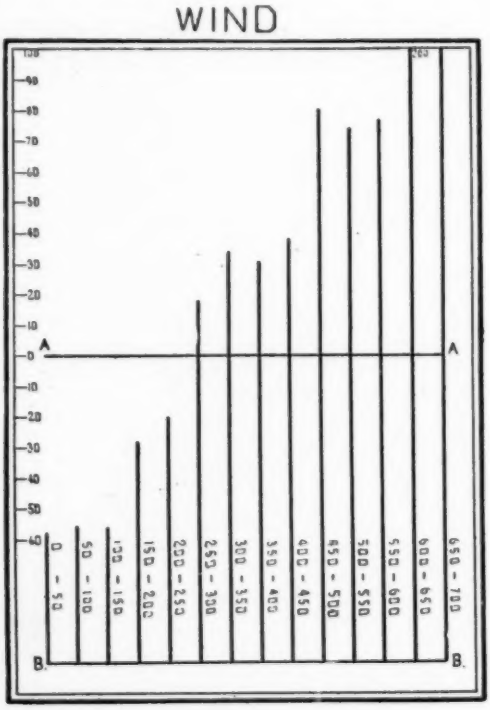


FIG. 6.

this would seem to prove that the mental states of the suicide and of the street brawler are very differently influenced by it.

It is difficult, in conclusion, to summarize the results of this study in such a manner as to be of much value or to bring forward theories which are certain of any long tenure of life. The whole method of the study is too new and untried, and the number of data inadequate. The bare facts revealed in the preceding paragraphs must prove of much more value than any hypothesis drawn from them at this stage of the investigation. Still, there are a few generalizations which seem worth noting, especially as they are based in part upon findings which are entirely con-

tradictory to popular opinion with regard to the time chosen by the suicide for the final act.

The first is that suicide is excessive under those conditions of weather which are generally considered most exhilarating and delightful —that is, the later spring months and upon clear, dry days. Reference to Figs. 1 and 2 proves this conclusively for the number of data and the locality studied. It was also noted that there were the greatest numerical excesses for the most agreeable temperatures. Barometrical conditions can hardly be referred to the categories agreeable and disagreeable, but for humidity and wind the relation will hardly hold, since we have the greatest excesses during high humidities and great wind velocities, both of which are unpleasant. Yet these facts would not invalidate our first statement, for neither high winds nor great humidities bring a scowl upon the face of Nature that can be compared with that of a wet, drizzling day. In fact, a day may be bright, and be both windy and humid. Yet these latter conditions have effects peculiarly their own, as shown conclusively by the study of deportment already cited. They are, for wind, the production of a neurotic condition in which self-control is in a marked degree lessened, and for high humidities the production of a minimum of vital energy. The former is shown especially in the study of the school children, and the latter of the death rate. These facts make it possible for us to amend our statement that suicides are excessive during the most noticeably delightful conditions, by adding: coupled with especially devitalizing ones.

But this does not in any way account for the seemingly anomalous effect of bright weather. To me the only plausible hypothesis is that of contrast. Investigation has seemed to prove that very few suicides are committed on the 'spur of the moment.' The act is generally premeditated, and its consummation deferred, sometimes again and again. We can hardly doubt, either, that it is dreaded, and the hope entertained, even to the end, that it may not need to be. During the winter months that hope must be centred on the belief that when Nature smiles with the spring sunshine all will be well; on the gloomy day, when the morrow comes with its exhilarating brightness, the present cloud of unhappiness will be gone. The love of life is still strong, and the grave can not be sought while there is still hope for better things.

But spring comes with all its excess of life, and the morrow with its brightness, but do not bring to the poor unfortunate, unable to react to these forces as of yore, the hoped-for relief. He thinks of other springs when the bluebirds sang happier songs, and of other sunshine which had set his blood tingling. The drowning man had waited long for the straw; it came and he clutched it, but it sank beneath his weight.

RECENT PROGRESS IN AERIAL NAVIGATION.

By CHARLES H. COCHRANE, M. E.

THE recent successful trips of the Zeppelin airship make it appropriate to review and illustrate some of the less known attempts at aerial navigation. Somewhat similar in plan to Count von Zeppelin's enormous airship is the dirigible flying-machine shown in Fig. 1, with which at various times during 1897 and 1898 Dr. K. I. Danilewsky, of Charkov, Russia, made excursions. The object of making the balloon sausage-shaped was, of course, that its forward end might be brought toward the wind, and then, with the nose pointed upwards, as in the illustration, its under surface served somewhat as that of a kite. The wings were made about twelve feet in length, and it was found

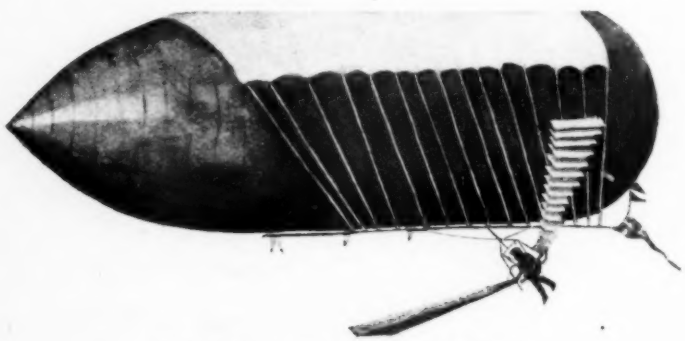


FIG. 1. DANILEWSKY'S DIRIGIBLE BALLOON.

possible to handle them so as to turn the balloon entirely around in the air, and also to keep it practically stationary in a moderate breeze.

M. de Santos Dumont has sailed about the Eiffel Tower in Paris in the dirigible balloon shown in Fig. 2. It was 65 feet long, 25 in diameter and contained 17,658 cubic feet of gas. He used a small petroleum engine for controlling the rudder and aeroplane. The reports are that he was able to navigate very much at will. Fig. 3 is another form of dirigible balloon tried by M. Dumont. This was also reasonably successful.

Fig. 4 represents a machine designed by Frederick R. Merritt, with windmill sails below and on both sides of his balloon, and a mechanism for feathering them in such a manner as to drive the craft either forwards or backwards.

Fig. 5 is a design of Theodore Liebrand. The cylinder is of aluminum, and the wings transform themselves into wheels when the machine runs along the ground. I have no record of the actual success of either Merritt's or Liebrand's inventions, or even of their trial.

Returning to the realm of actual experiment, in Figs. 6 and 7 are shown views of Carl E. Myers's 'sky-cycle.' Of this Mr. Myers

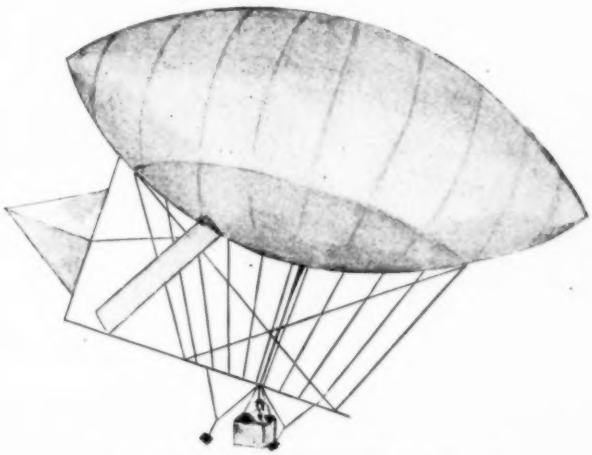


FIG. 2. SANTOS DUMONT'S DIRIGIBLE BALLOON (I).

FIG. 3. SANTOS DUMONT'S DIRIGIBLE BALLOON (II).

writes, under date of February 5, 1900, with the enthusiasm of the inventor:

"The sky-cycle, or gas-kite, is a hand and foot propelled air-ship, provided with revolving screw-sails, vibrating wings, movable aeroplanes and universal rudder—the object of the entire equipage being to test

the relative advantages of all known systems for propulsion and guidance, and to attain practical experience in manipulating air craft. The operator and machinery are suspended below a peculiarly shaped gas-spindle, whose fabric has been treated by a special process, original with me, which enables it to retain hydrogen permanently during use. It has within a limited period made upwards of one hundred flights, embracing New York State, Massachusetts, New Hampshire, Maine,

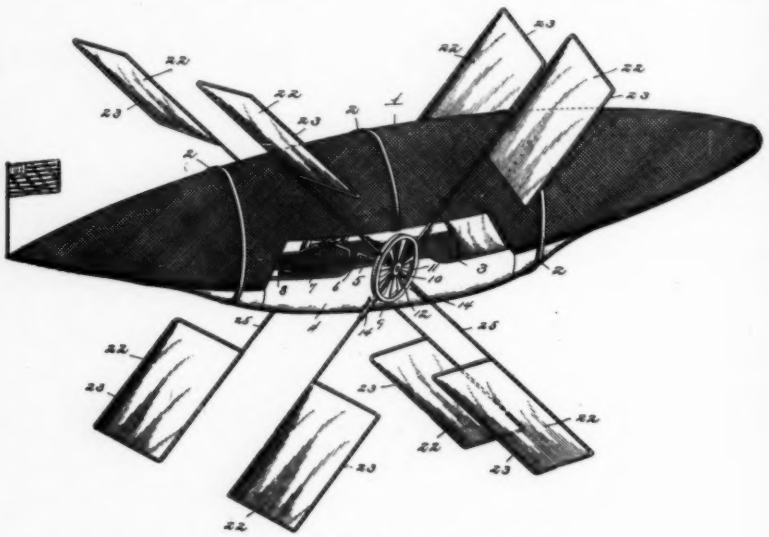


FIG. 4. MERRITT'S FLYING MACHINE.

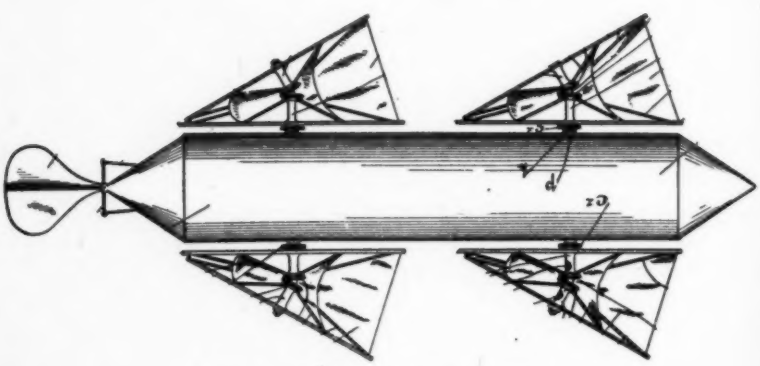


FIG. 5. LIEBRAND'S FLYING MACHINE.

Delaware, Connecticut, New Jersey, Pennsylvania, Maryland, Virginia, Tennessee, Ohio, Michigan and Illinois.

"Three machines only have been built, varying somewhat in form of spindle and extent of surface handled. As used at present, the screw, formerly fifteen feet diameter, has been reduced to eight feet, and the wings and rudder abandoned, the universal-jointed aeroplanes on each side having proved in every way superior for all evolutions.

"With practice acquired by use of the sky-cycle, and with some indicated variation in structure and equipment, including a light automotor engine of best type, there should be no great difficulty in accomplishing an overland transcontinental journey by two or three persons with this type of air craft in less time than the same trip could be made by the same party on the ground."

In Fig. 6 the gas-kite shown is a concavo-convex gas-vessel, like an upturned canoe. It is drawn forward by the screw-sail, which is rotated by hand and foot power. The steering is done by tipping to change the level or direction. In Fig. 7 the sky-cycle is shown tipping downward in the act of circling to the left in a descending spiral, the aeronaut using both screw-sail and small aeroplanes.

Jerome B. Blanchard, of Highlands, Col., patented in 1894 the aeroplane flying-machine shown in Fig. 8. He disdains the balloon

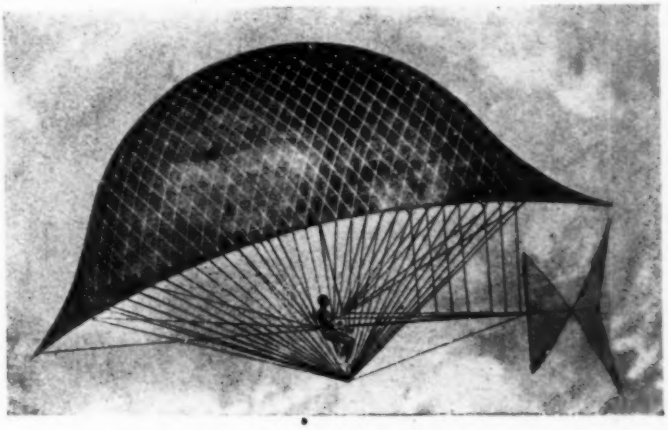


FIG. 6. MYERS'S SKY-CYCLE (I).

and depends entirely on the two aeroplanes and the speed of the aviator to maintain the vessel in the air. The plan is to start the machine along an elevated tramway until a lifting speed is acquired, and then to depend upon the muscular exertion of the occupant.

Of a more practical character is the 'trolley flyer' of Daniel C. Funcheon, of Valderde, Col., illustrated by Fig. 9. A drum is supported on a platform and hung from an aeroplane. Around the drum coils a wire that may be made to convey a current of electricity for propelling the mechanism. Of course, the machine would require propellers and balancing devices, which are not shown in the drawing.

Fig. 10 represents a machine actually built and tried by Arthur Steutzel, of Altona, Prussia, in 1896. The wings were eleven feet long, and were flapped by the power of a carbonic acid gas-motor in the receptacle below. The rudder was designed to maintain the course

set, and the wire simply to support the machine at the start. When the motor developed one and a half horse-power the stroke of the wings was sufficient to raise it and cause a jump along the wire. The total weight of the apparatus was about seventy-five pounds, and the motor could be run to develop three horse-power for a little time, and with that power it flew along in an interesting manner.

In studying the principles of mechanical flight, many experimenters have made little flying toys and have launched them in the air to see how they worked. M. Pichancourt made a number of these, with twisted rubber as motive power, but no one of them ever sailed more than sixty-three feet. Prof. S. P. Langley had greater success in this

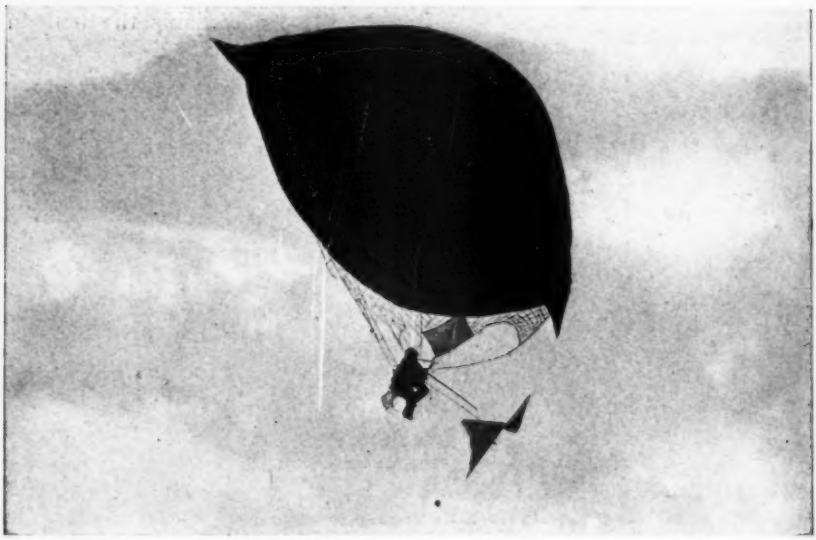


FIG. 7. MYERS'S SKY-CYCLE (II).

direction, and one of the rubber motor toys is shown in Fig. 11. I do not know how far it flew. Lawrence Hargrave made use of a tube of compressed air, on which were mounted wings that vibrated as long as the air furnished enough power. He built one of these, seven feet in length, that weighed only fifty-nine ounces, and it flew 350 feet. Another form of toy, designed to be thrown from a high station, is shown in Fig. 12. Several of these were built by James Means and launched from the top of a lighthouse in Boston harbor. The length was about six feet, and they sailed a considerable distance.

Mr. Beecher Moore, of Buffalo, N. Y., has originated the very interesting machine shown in Fig. 13. Mr. Moore states that the working model which he constructed was charged with a slow-burning mixture of saltpeter, sulphur and charcoal, and would fly about 500

feet, or until the mixture was burned out. He claims that it sails along evenly, balancing perfectly, and that it may be steered by the rudder. He prefers to fill the tank of the car with liquid air, on the ground that it furnishes a maximum of stored power with light weight. The air is exhausted and expanded through the nozzle at the top of the pipe. Mr. Moore says:

"The nozzle is placed at the top of the pipe, so that the push will act directly on the string of the kite and not push the car out of plumb, nor disturb the equilibrium of the machine. The kite is attached to the machine by wires, which allows it to balance itself automatically. This property would be destroyed if it was attached rigidly

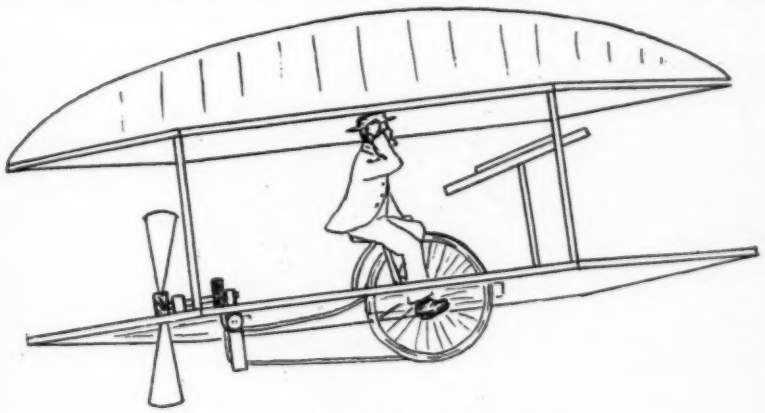


FIG. 8. BLANCHARD'S FLYING MACHINE.

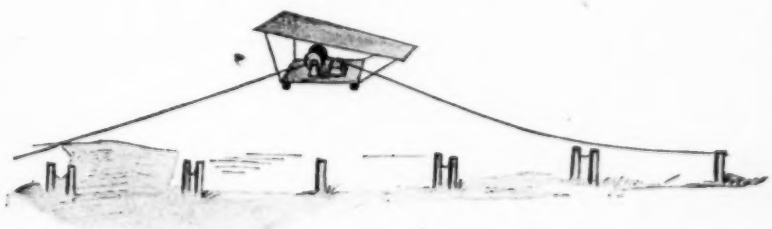


FIG. 9. FUNCHEON'S 'TROLLEY FLYER.'

to the balance of the machine. The method of attaching the wires is original and adds to the stability of the kite. The wheels are not necessary for the locomotion of the machine in the air, but are necessary in starting and alighting. In starting the machine, it is placed in an open road, and when the power is applied it runs along on the ground, gathering speed and giving the kite lifting power. When the machine has attained the necessary speed, it will leave the ground at a slight angle and continue in the air as long as it is forced ahead at sufficient speed to sustain its weight on the aeroplane. In alighting, the power should be shut off slowly until the machine settles to the ground, where it would slow down and stop."

Mr. Moore is a strong advocate of the rocket-like form of propulsion for flying machines. He admits that it is wasteful as far as expense is concerned, but contends that it will make a machine go where propellers will fail. He claims that the propeller "is very wasteful of power from friction of the blades in the air, and from 'end stroke,' or currents of air set in motion in the wrong direction." He says further:

"I have studied and experimented extensively with small aeroplane

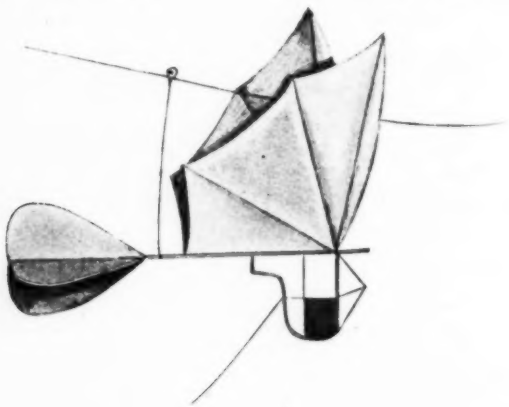


FIG. 10. STEUTZEL FLYING MACHINE.

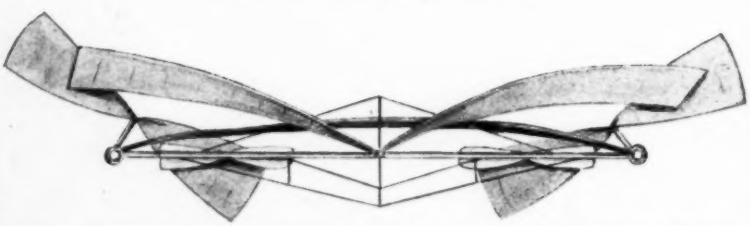


FIG. 11. LANGLEY'S MODEL FOR STUDYING THE PRINCIPLES OF MECHANICAL FLIGHT.

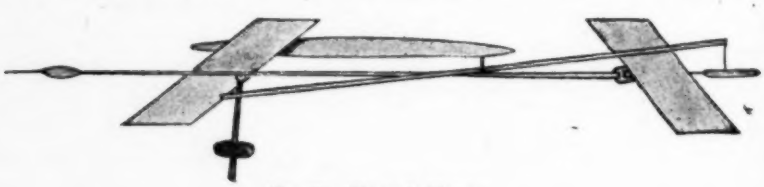


FIG. 12. MEANS'S MODEL.

machines of every conceivable shape to test their balancing power, and have concluded that it is impossible to build a compact aeroplane machine that will balance and be under control in the air, with present known means. The aeroplane machine of the average inventor consists of aeroplanes elevated in various manners, and most of the weight arranged below to give them stability and keep them from upsetting.

This may appear all right in theory, but actual experiments will at once demonstrate that any compact aeroplane machine, with sufficient aeroplane surface to support the accompanying weight, will sway, turn sideways and upset, with all manner of erratic and unexpected movements.

Some four years ago M. Ader, a French engineer, attracted a great deal of attention with a machine styled the 'Avion.' It had a car running on four wheels, two propellers forward to pull it along, and

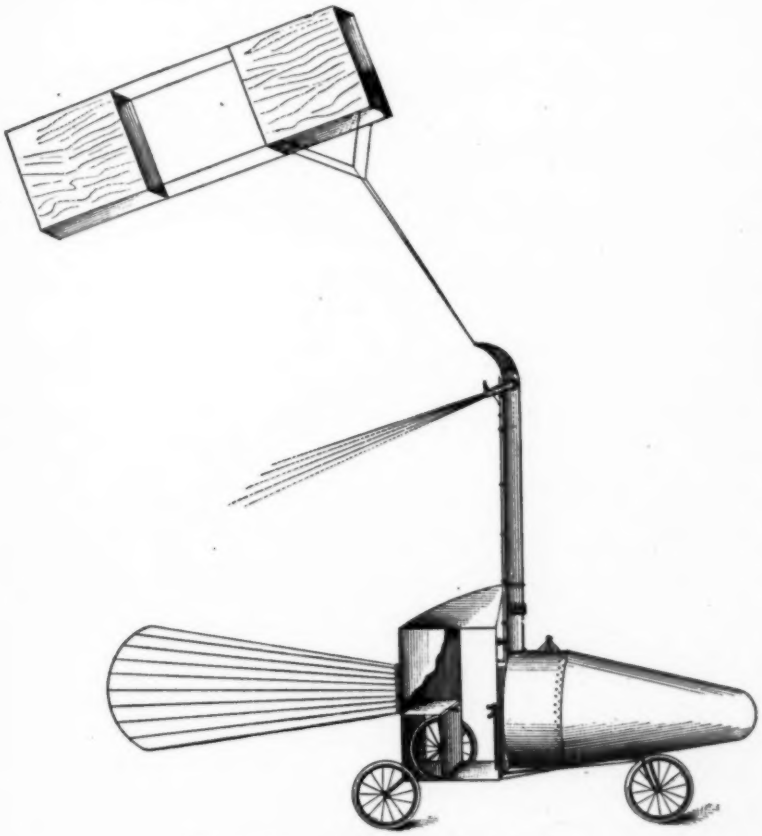


FIG. 13. BEECHER MOORE'S FLYING MACHINE.

two enormous bat-like wings. The wings were designed to assist in soaring and in sustaining the mechanical bird in flight, when enough speed was secured to carry it off the ground. The machine did fly a little, but, unfortunately, like Maxim's famous machine, described in the POPULAR SCIENCE MONTHLY a few years ago, broke down just as it demonstrated that it had enough lifting power to get off the track. Fig. 14 shows the 'Avion' as it was designed to appear in flight.

George L. O. Davidson, an English engineer, a year or two ago designed a bird-like machine, to be built of steel, and to sail along with spread wings, on the principle of a Lilienthal soaring apparatus, but I have never learned that the machine got beyond the stage of being represented in drawings.

This article would not be complete without a reference to Prof. S. P. Langley's aerodome, shown in Fig. 15. It has, however, been described so fully that it is only necessary to refer to it here.

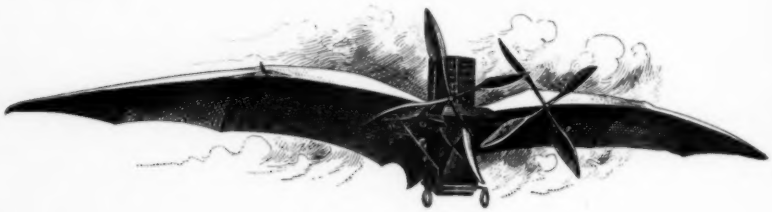


FIG. 14. THE AVION.

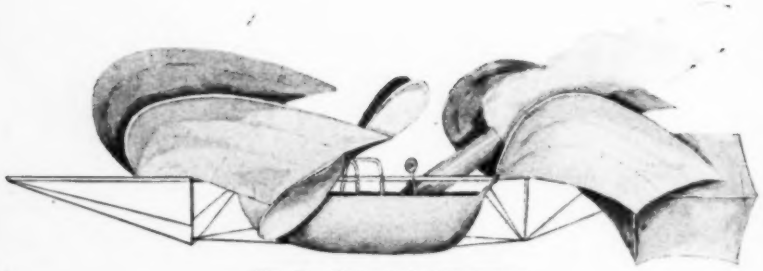


FIG. 15. LANGLEY'S AERODOME.

The conclusion may be fairly drawn from these brief descriptions of experiments in aerial navigation, that the aerodrome is supplanting the balloon, but that it can not as yet be used alone successfully. All the flying machines that depend solely upon a motive power and supporting planes are unable to carry any large supply of fuel, and descend after a short flight. The balloon can remain in the air a long time, but it is unwieldy. The practical inference is that some combination of the balloon and the aeroplane is necessary to produce a machine that will be of commercial use in aerial navigation.

THE FOREIGN TRADE OF THE UNITED STATES.*

By FREDERIC EMORY,
CHIEF OF THE BUREAU OF FOREIGN COMMERCE.

DURING the calendar year just ended, the inundation of foreign markets by American goods proceeded on the lines indicated in previous issues of the 'Review of the World's Commerce,' with a constantly growing volume and force which have surmounted many difficult obstacles and offer a strong temptation to overconfidence in our capabilities as an exporting nation. At the present time, the United States may be said to be nearing the top wave of industrial eminence, and there is ample reason for the belief that the next few years will witness a great expansion in the sale of our more highly developed manufactures. But in the annual reports of our consular officers for the year 1900, there runs, along with a common note of satisfaction, a warning, here and there, of a more strenuous competition which, in the end, may counterbalance our superior advantages to a considerable extent and check our progress in the world's markets, unless we equip ourselves in the meantime for the ultimate phases of the struggle.

Nothing could well be more gratifying than the picture of our foreign trade as it is to-day by comparison with the figures of very recent years. It is all the more remarkable because our progress has been achieved with but little effort and by means not directed specifically to the promotion of foreign trade, but largely fortuitous, and springing from our intense absorption, for many years, in domestic industry and internal development. In other words, we have reached a surprising eminence in the exportation of manufactured goods, not because we were seeking that goal, but because, in developing our resources, in manufacturing for the home market, we attained an excellence and comparative cheapness of production which, to the astonishment of ourselves as well as of the world at large, has suddenly made us a formidable competitor—perhaps the most formidable of all—in the great international rivalry for trade.

The question for the future is whether we can permanently hold the position we seem about to gain, by means of what may be termed

* From advance proof sheets of the 'Review of the World's Commerce,' introductory to 'Commercial Relations of the United States,' 1900. The 'Review' will also be printed as a separate pamphlet. Applications for it, as also for the two bound volumes, 'Commercial Relations,' should be addressed to the Chief of the Bureau of Foreign Commerce, Department of State, Washington, U. S. A.

our purely domestic advantages of economy of production, greater labor efficiency and cheap raw materials, or whether we shall not have to fight hard against nations now falling behind us with weapons specially fashioned for controlling foreign trade—as, for example, more scientific export methods, better facilities of banking and transportation, more liberal credits, and manufacturing for particular markets with intelligent regard to climatic and race requirements. Many of our consuls still tell us that our commercial activity abroad is almost primitive in the details of trade competition, although of late our exporters have begun to send capable representatives to the more important trade centers; and the past few years have witnessed the creation of important trade organizations in the United States for the study of foreign commerce, the adoption of special courses of commerce at a number of our colleges, and the establishment of sample rooms and agencies for the sale of American goods at a few of the entrepôts of countries which offer a favorable field. Meanwhile, foreign manufacturers are introducing our labor-saving machinery or imitating it, and European economists are urging industrial reforms or legislative enactments to meet our threatening competition.

GROWTH OF MANUFACTURED EXPORTS.

During the year ended December 31, 1900, according to United States Treasury returns,* the imports of the United States amounted in round numbers to $830,000,000, an increase of over $30,000,000 compared with 1899, while the exports aggregated $1,478,000,000, an increase of $202,480,000. The exports in 1900 exceeded the imports by $648,900,000. Of the exports, the percentage of manufactured goods rose to 31.54† for 1900, against 30.39 in 1899, 24.96 in 1898, and 24.93 in 1895. Of the imports, nearly 45 per cent., it is estimated by the Treasury, were materials, either crude or partly made up, for use in our manufacturing industries, an increase of over 35 per cent. in 1899 and 1900, as compared with the entire period from 1890 to 1898. In other words, our industrial growth continued in 1900 at a rapid pace, enabling us to take less finished goods from other countries and to furnish more.

PREDOMINANCE IN IRON AND STEEL.

The most striking fact in our export development is the remarkable growth of the foreign demand for our iron and steel, our exports amounting to nearly $130,000,000 in 1900, against $32,000,000 in 1895.

---

* Preliminary figures from the Bureau of Statistics, December, 1900.

† Later returns give the percentage as 30.38. This decline is attributed to the increase in the proportion of agricultural exports at the end of the year; also to the decrease in exports of copper ingots and cotton cloths, the latter mainly to the Chinese Empire.

In an article in the New York 'Evening Post' of January 12, 1901, Mr. Andrew Carnegie says the United States has not only supplied its own wants, 'but is competing to supply the wants of the world, not only in steel, but in the thousand and one articles of which steel is the chief component part,' and expresses the opinion that the increasing demand from the world at large 'can be met only by the United States.' "The influence of our steel-making capacity," adds Mr. Carnegie, "must be marvelous, for the nation which makes the cheapest steel has the other nations at its feet as far as manufacturing is concerned in most of its branches. The cheapest steel means the cheapest ships, the cheapest machinery, the cheapest thousand and one articles of which steel is the base."

CHEAPNESS OF AMERICAN GOODS.

It is the relative cheapness of American steel that has given it preeminence, and it is the same with other products that are winning their way abroad. Economy of production is the master key that unlocks for us markets that seemed a little while ago to be inexorably closed. This economy of production implies not merely low prices to the foreign consumer, but a greater degree of excellence, a superior adaptation to his wants. As has been pointed out in the 'Reviews,' as well as elsewhere, the American workingman, though receiving higher wages, produces, with labor-saving machinery, at a lower unit of cost, and his greater application and ingenuity enable him to avail himself effectively of the most recent inventions and appliances for improving the quality of his special line of work. The American factory system is highly organized and more efficient than any other, and, if our export trade were as well developed, there would be little to fear. The only lesson our manufacturers need to learn, it would seem, is the necessity of manufacturing especially for foreign trade; and the great increase of requests for information from our consuls as to the kinds of goods wanted in particular markets, and also of manufacturing processes employed in this or that line of industry, encourages the hope that there is beginning to be a general perception of this important fact.

BRITISH ESTIMATES OF AMERICAN PROGRESS.

It is evident that foreign observers are keenly alive to the greater efficiency of our industrial methods, and are seeking earnestly to profit by them. A writer in the London 'Times' of December 29, 1900, attributes the American manufacturer's advantages over the British largely to the consideration shown to young men and the willingness to utilize their energy and enterprise. He lays stress upon the fact that it is customary for American fathers "to discuss their business affairs with

their sons in a way that is quite surprising to an Englishman," and adds:

A good many years ago, I spent a few evenings with some students of one of the large American colleges. I was new to America then, and heard with surprise these college youths discussing questions that arose out of the business in which their fathers were engaged. If we compare this with what generally happens when lads of our own public schools or young men at our own universities meet together—when any mention of the paternal shop would be looked on as the worst of bad form—I think perhaps there will be seen one of the reasons why Americans are fitted to control business at an earlier age than is usual in this country.

The American youth, as pointed out, obtains his business education from practical experience and social intercourse, and this form of education is held to be 'immeasurably above the mere learning of lessons which too often goes by the name of education.' Another reason for the adaptability of American youth to business is stated to be the public-school system, which is 'more truly educational, less pedagogic.' In conclusion, the 'Times' correspondent says:

To me, it appears one of the most disquieting factors in the problem before us (industrial competition) that the United States have trained a body of young men who are determined to make their country great, and who have been educated to a living, practical interest in the things needful to that end.

The 'Times,' commenting editorially on these views and upon others expressed in a previous series of articles, says: "The threatened competition [of United States manufacturers] in markets hitherto our own comes from efficiency in production such as has never before been seen," and accepts the view that this efficiency is to be ascribed, to a large extent, to the practical self-education of Americans, which enables them generally to enter business 'with a stock of knowledge of which the young Englishman fresh from the university or a public school has not an inkling.' Further on the 'Times' says:

In the interesting analysis of the causes at work adverse to England, something might be said of the great intelligence and zeal put into affairs. The American man of business takes his pleasure in what he is doing, and never fails when he is traveling to look out for hints to be applied when he returns home. Not afraid to admit that he is 'in pork' or 'in grain,' if the fact be so, he is curious as to all that affects his business, and he is open to new ideas in a way which is unusual with us. 'What has succeeded in the past will not succeed in the future' is a working maxim with the best men of business, who are ready to throw their experience as well as their antiquated machinery on the scrap heap. There are some signs of a change in this respect in this country: but the idea that there is something respectable, solid and satisfactory in doing in the mill, workshop and counting house what one's father did dies hard.

The London 'Spectator' of December 29, 1900, quotes 'a competent writer' in a British trade paper as saying:

From a careful calculation, made after comparing notes with other observers,

and taking the figure 1 to 1¼ as representing the producing capacity of the ordinary British workman, I consider the Swiss-German as fairly represented by 1¼ and the Yankee by 2¼.

In an article entitled 'America's Changed International Position,' the London 'Statist' of January 5, 1901, also dwells upon the superiority of our methods of production as enabling us to take advantage of the needs of Europe and to respond to an increased demand for manufactured goods. "All at once," says the 'Statist,' "the United States became a keen competitor in the markets of the world with ourselves and with our continental rivals, and, in all reasonable probability, the competition will grow more eager as the years pass." The 'Statist,' in fact, predicts 'a great outburst of new enterprise in the United States.'

CONCENTRATION OF CAPITAL IN THE UNITED STATES.

Lord Rosebery is quoted by cable as having said in a speech before a British Chamber of Commerce, January 16, 1901, that the chief rivals to be feared by Great Britain 'are America and Germany.' "The alertness of the Americans," he continued, "their incalculable natural resources, their acuteness, their enterprise, their vast population, which will in all probability within the next twenty years reach 100,000,000, make them very formidable competitors with ourselves. And with the Germans, their slow but sure persistency, their scientific methods, and their conquering spirit, devoted as these qualities are at this moment to preparation for trade warfare, make them also, in my judgment, little less redoubtable than the Americans. There is one feature of the American competition which seems to me especially formidable, and, as I have not seen it largely noticed, perhaps you will excuse me for calling attention to it. We are daily reminded of the gigantic fortunes which are accumulated in America, fortunes to which nothing in this country bears any relation whatever, and which in themselves constitute an enormous commercial force. The Americans, as it appears, are scarcely satisfied with these individual fortunes, but use them by combination in trusts, to make a capital and a power which, wielded as it is by one or two minds, is almost irresistible, and that, as it seems to me, if concentrated upon Great Britain as an engine in the trade warfare, is a danger which we cannot afford to disregard. Suppose a trust of many millions, of a few men combined so to compete with any trade in this country by underselling all its products, even at a considerable loss to themselves, and we can see in that what are the possibilities of the commercial outcome of the immediate future."

It has been evident for some time that the United States, not content with having solved that part of the problem of economy of produc-

tion which relates to processes of manufacture and the utilization of labor, has been drifting instinctively towards the larger question of the concentration of capital as the logical development of the same general idea of reducing cost and increasing the margin of profit. The question is larger because it has a more direct and more general bearing upon the economic and social life of the nation, upon the interests, real or imagined, of the whole body politic. We have to do with it here only because of its relation to and possible effect upon our foreign trade, and it is interesting to know that so thoughtful an observer as Lord Rosebery perceives in the simplification of the use of capital in the United States which is going on—it may be said experimentally, to a large extent as yet—a tremendous power in the commercial rivalry of the world.

GERMAN VIEWS OF AMERICAN COMPETITION.

Germany, as well as Great Britain, seems fully sensible of the seriousness of American competition. In a recent issue, the Hamburger 'Fremdenblatt'* points out that the United States, which ten years ago exported more than 80 per cent. of agricultural products and less than a fifth of manufactured goods, to-day draws nearly a third of its entire exports from the products of its factories. "In other words, the Union is marching with gigantic strides towards conversion from an agricultural to an industrial nation." "Does not the rapid increase of the United States in the value of industrial exports," the 'Fremdenblatt' asks, "constitute an imminent danger from all competing nations?" Continuing, the 'Fremdenblatt' says:

> If we now turn to an investigation of all the elements which have produced this tremendous, this almost incredible, revolution in the world's situation, it is impossible within our present limits to consider all the factors which are of importance to German interests as well as essential to a comprehensive conclusion. Competent experts, well informed as to the industrial and export conditions which prevail in the United States, have established the following facts:
>
> The steel manufactories of the United States, which two decades ago were in their infancy, to-day control the markets of the world, dictate either directly or indirectly the prices of iron and steel in all countries, and partly through the richness of their supply of iron ores and coal, partly by the use of labor-saving machinery and skilful, effective means of transportation, have attained a position to not only compete with the older iron and steel-producing countries, but even to profitably export their products to England.
>
> American tools, especially hatchets, axes, files, saws, boring implements, etc., enjoy, by reason of their excellent quality, the best reputation, and, in spite of their higher price, stand above competition in nearly the whole world. Also in sewing machines, bicycles and agricultural implements of every kind, the United States has begun to drive England and Germany from the world's

* Article translated by Consul-General Mason. See 'Advance Sheets' No. 934 (January 14, 1901).

markets, especially that of Russia, which may be partly attributed to the fact that American firms are protected in their own market from foreign competition and can thus sell their manufactures cheaper abroad than at home.

A remarkable change has also taken place in the field of boot and shoe production. Hardly more than ten years ago the United States imported shoes from Europe—especially women's footwear from Austria, while other grades were made of leather imported from England and Germany. To-day, it not only makes its entire supply of leather at home and exports it in considerable quantities, but it floods Europe with ready-made shoe depots in Paris and even in the principal cities of Germany.

That the United States, by reason of its richness in mineral oils and aided by its unrivaled facilities for refining and transporting this international necessity, controls the petroleum trade of the world and is held in check only by Russia is well known, and the fact is only cited here in order to include this weighty factor in the calculation. The experience of the past few months proves that within a not far distant period, the coal of the United States will play the same rôle in the markets of the world. The Union has reversed the old adage, "It is ridiculous to carry coals to Newcastle," for to-day anthracite coals from Pennsylvania are actually exported to England.

Incidentally, it may be remarked that the typewriting machine with which this article is written, as well as the thousands—nay, hundreds of thousands—of others that are in use throughout the world, were made in America; that it stands on an American table, in an office furnished with American desks, bookcases and chairs, which cannot be made in Europe of equal quality, so practical and convenient, for a similar price. The list of such articles, apparently unimportant in themselves, but in their aggregate number and value of the highest significance, could be extended indefinitely. But it would seem more interesting and characteristic to cite the fact that an American syndicate is now planning, and has even taken the initial steps in a scheme, to take in hand the whole sleeping-car service of Europe, to improve it and make it cheaper than is now possible. Moreover, American manufacturers of underclothing, gloves and men's clothing, as well as women's cloaks—all articles which a few years ago were exported in vast quantities from Europe to the United States—are already beginning to calculate how they can place their surplus output in European markets.

The 'Fremdenblatt's' conclusion is that Europe "must fight Americanism with its own methods; the battle must be fought with their weapons, and wherever possible their weapons must be bettered and improved by us. Or, to speak with other and more practical words, Germany—Europe—must adopt improved and progressive methods in every department of industry; must use more, and more effective, machinery. Manufacturers as well as merchants must go to America, send thither their assistants and workingmen, not merely to superficially observe the methods there employed, but to study them thoroughly, to adopt them, and wherever possible to improve upon them, just as the Americans have done and are still doing in Europe."

SERVICES OF UNITED STATES CONSULS.

Dr. Vosberg-Rekow, head of the German bureau for the preparation of commercial treaties, attributes the remarkable growth of exports

of American manufactures to Europe, in part, to the activity of our consular service. "The United States," he says, "has covered Europe with a network of consulates and makes its consuls at the same time inspectors of our exports and vigilant sentinels, who spy out every trade opening or advantage and promptly report it." Dr. Vosberg-Rekow also dwells upon the eminently practical character of American industrial and business methods. "Germany's industrial advancement," he says, "is principally due to the thoroughness of her technical education. It is strengthened by the continuous substituting of machinery and machine tools for hand labor. Still, in this respect, the English industry in some branches is ahead of us. It is worthy of note that in this evolution, too, the United States has the foremost place and has made gigantic strides, not only in applying machine tools, but in inventing and manufacturing them, so that to-day she supplies us. This signalizes in an extraordinary degree American intelligence. Thus, the Americans, though wanting our superior technical education, thanks to their practical eye, improve upon our methods and apparatus. Theirs is rather the activity of an experimentalist than that of a trained craftsman; but a clever faiseur, if he but have assurance and luck, may distance the educated master. The Americans have no thorough education; nor do they possess a modern industrial system as we Europeans understand the term. The American applies himself to a single branch or to a specialty, with utter disregard of European methods and their results; he devotes to his work an amount of energy which stupefies Europeans; and, for awhile, he succeeds in driving us out of the line of articles on which he has centered his energy. Against such peculiar activity a general trade policy is quite ineffectual; we must put ourselves in condition to counteract this artificially forced growth of specialized industry."

EDUCATION IN BUSINESS.

Thus we find that expert opinion in Great Britain and Germany coincides in the conclusion that Americans, too eager to be up and doing to apply themselves to preparatory study or to what may be termed a general scheme of education and culture for industry and trade, have, nevertheless, worked out in practise a degree of actual efficiency, not learned from books, which gives them a distinct advantage. It is not to be denied, upon the other hand, that technical schools and special courses of commercial education might greatly enhance our capabilities, if care were taken to prevent them from usurping too far the practical business or industrial training which seems to be the secret of our success thus far. In the more and more strenuous competition which is evidently waiting us, our manufacturers, exporters and trade representatives abroad will need to be

provided with a variety of information which cannot be acquired except by academic instruction. The knowledge gained in the workshop or the counting house will not suffice to meet a rivalry which is seeking to equip itself, so far as it can, with our machinery, our industrial and trade methods—with everything, in short, that now gives us supremacy—and will add to these the mastery of details of trade conditions and industrial processes throughout the world, which we are only beginning to study.

FINANCIAL INDEPENDENCE OF THE UNITED STATES.

There is another feature of American influence in the world's markets which is, perhaps, even more notable than our industrial progress, and that is our suddenly acquired financial independence. The 'Hamburger Fremdenblatt' article previously quoted from points out that it is the logical result of our growth in industry and trade and especially of our successful competition in foreign markets. As soon as American industries, through various causes, found themselves in a favorable financial condition, "they likewise undertook the task of freeing themselves from foreign capital—in other words, of reclaiming the industrial securities which were in European hands." "The change in the condition of the United States," adds the 'Fremdenblatt' "can best be characterized by the statement that the industries, trade, agriculture, railroads and finances of the Union each and all climbed, one upon another, through and by each other, steadily upward. And to what a height they have climbed!"

During the past year, the point was reached where the United States became a lender of money to other countries instead of a borrower from them. "Speaking roughly," says the London 'Statist' (January 5, 1901), "the holdings of American securities in Europe now are immensely smaller than they were ten years ago, and the purchases have been made by the Americans out of the vast savings accumulated, first, during the anxious period from 1890 to 1896, and, secondly, during the prosperous period that has followed. Many countries, however, are able to buy back their own securities without being in a position to take an important place in the international investment market. For example, Spain has bought back a very large proportion of her own securities. In the United States, not only has the buying back of American securities been on the great scale indicated, but during the past year or two, American capitalists have lent largely to Europe. At the end of 1899, when there was great pressure in the money markets of Europe, about four millions of gold were allowed to be shipped from New York to London; and during the past year it will be recollected that gold was sent in considerable amounts, while about five millions sterling were invested in [British] Government

funds. German Government funds were also bought amounting to about four millions sterling. Russia was able to borrow in order to purchase railway material. And it is understood that the United States was willing to lend likewise to Switzerland and to other governments. This is the most dramatic change that has occurred for a very long time."

"The succession of extraordinary creditor balances," says the 'New York Journal of Commerce,' of January 10, 1901, "has virtually revolutionized our financial relations with the European centers. In a very important sense, we have become the creditor nation of the world. From a chronic condition of dependence upon the banking forces of London, Paris and Berlin, we find those centers now dependent upon the large floating balances of the United States, subject to our lending ability in periods of exigency, carrying the largest stock of gold in the world and holding the largest resource for dealing with crises in international finance. Three of the foremost European governments—England, Germany and Russia—have found it necessary to come to New York for important loans, and the two former have not applied in vain. Thus, if this city may not be said to have yet become the financial center of the world, yet we may incontestably claim a foremost rank among the few metropolitan cities which have won that distinction."

"One of the most important financial features of the year," says 'Bradstreet's' (January 5, 1901), in its review of the stock-market in 1900, "was the placing in Wall Street and with American investors of issues of British consols, German Government bonds, and loans by Russia, Sweden, and other countries, giving point to the feeling that our market has taken the lead in the financial world."

THE FUTURE OF INTERNATIONAL COMPETITION.

Summed up, therefore, the general conclusion of competent foreign authorities, as well as of our own, is that the commercial expansion of the United States is no longer problematical, but a fact of constantly enlarging proportions which opens up new vistas in the struggle for ascendency among the industrial powers. Prolific as it has been of great surprises, it is doubtful whether similar phenomena will spring from its undemonstrated forces. It would seem, now that the causes of our unlooked-for triumphs are known and are being carefully weighed and studied, that the future will be one of fruition, of the gradual maturing of our powers, rather than of sudden blossoming of some novel capacity of competition. The day, perhaps, is not distant when the more intelligent of our rivals will be able to meet us upon more nearly equal terms and when, as has already been indicated, it will be necessary to supplement our natural advantages and our highly developed industrial efficiency with the appliances of educa-

tion, of special training, of technical skill, of more scientific methods of extending trade, which have already secured rich returns—to Germany, for example—in quarters of the globe where our goods, as yet, have made but little if any headway.

GENERAL SUMMARY OF TRADE.

When we come to survey the field of international competition, as described by our consuls and in the light of comments by foreign economists and trade authorities, we find some highly significant indications of the probable course of trade currents within the next few years. As to the general march of our commercial expansion in the immediate future, the reports of the consuls emphasize the conclusions to be drawn from the most recent figures of the United States Treasury. According to a statement issued by the Bureau of Statistics of that Department for the decade ended with the calendar year 1900, our imports, which in 1890 were $823,397,726, were in 1900 $829,052,116, an increase of less than 1 per cent. in the decade; while our exports, which in 1890 were $857,502,548, were in 1900 $1,478,050,854, an increase of 72.4 per cent. In 1890, the excess of exports over imports was $5,654,390; in 1900, it was $648,998,738.

"In our trade relations with the various parts of the world," continues this statement, "the change is equally striking. From Europe, we have reduced our imports in the decade from $474,000,000 to $439,000,000, while in the same time we have increased our exports from $682,000,000 to $1,111,000,000. From North America, imports fell from $151,000,000 in 1890 to $131,000,000 in 1900, while our exports to North America increased during that time from $95,000,000 to $202,000,000. From South America, the imports increased from $101,000,000 in 1890 to $102,000,000 in 1900, while to South America our exports increased from $35,000,000 to $41,000,000. From Asia, the imports into the United States increased from $69,000,000 in 1890 to $123,000,000 in 1900, while to Asia our exports in the same time increased from $23,000,000 to $61,000,000. From Oceania, the importations in 1890 were $23,000,000 and in 1900 $23,000,000, while to Oceania our exports in 1890 were $17,000,000 and in 1900 $40,000,000. From Africa, importations increased from $3,000,000 in 1890 to $9,000,000 in 1900, and exportations to Africa increased from $4,500,000 in 1890 to $22,000,000 in 1900."

The changes in the movements to and from the continents are attributed by the Bureau of Statistics to two great causes: First, the increase at home of manufactures which were formerly drawn chiefly from abroad; and, second, the diversification of products, by which markets are made for many articles which formerly were produced or exported in but small quantities. "From Europe, to which

we are accustomed to look for manufactures, our imports have fallen over $35,000,000, while Europe has largely increased her consumption of our cotton-seed oil, oleomargarine, paraffin, manufactures of iron and steel, copper, and agricultural machinery, as well as foodstuffs and cotton, our exports to that grand division having increased $428,000,000 since 1890. From North America, the imports have fallen $20,000,000, due chiefly to the falling off of sugar production in the West Indies, the imports from Cuba alone having decreased from $54,000,000 in 1890 to $27,000,000 in 1900. To North America, the exports have increased meantime over $100,000,000, the growth being largely manufactures and foodstuffs, a considerable portion of the latter being presumably re-exported thence to Europe. From South America, the imports have increased in quantity, especially in coffee and rubber, but decreased proportionately in price, so that the total increase in value in the decade is but $1,000,000, while in exports the increase is $6,500,000, chiefly in manufactures. From Asia, the importations have increased more than $50,000,000, the increase being chiefly in sugar and raw materials required by our manufacturers, such as silk, hemp, jute and tin; while to Asia the increase in our exports has been nearly $40,000,000, principally in manufactures and raw cotton. From Oceania, the imports show little increase, though this is due in part to the absence of statistics of importations from Hawaii in the last half of the year 1900; while to Oceania, there is an increase in our exports of more than $20,000,000, chiefly in manufactured articles. From Africa, the increase in imports is $6,000,000, principally in manufacturers' materials, of which raw cotton forms the most important item; while our exports to Africa increased meantime $17,000,000, chiefly in manufactures."

The following tables show the imports and exports of the United States by grand divisions in the calendar years 1890 and 1900. In the figures showing the distribution by continents in 1900, the December distribution is estimated, though the grand total of imports and exports for 1900 is based upon the complete figures of the Bureau of Statistics:

Grand Divisions.	Exports from United States.		Imports into United States.	
	1890.	1900.	1890.	1900.
Europe	$682,585,856	$1,111,456,000	$474,656,257	$439,500,000
North America	95,517,863	202,486,000	151,490,330	131,200,000
South America	34,722,122	41,384,000	100,959,799	102,000,000
Asia	22,854,028	60,598,000	68,340,309	122,800,000
Oceania	17,375,745	39,956,000	23,781,018	23,400,000
Africa	4,446,934	22,170,000	3,169,086	9,900,000

NEW CURRENTS OF TRADE.

Besides the surprising development of our sales of manufactured goods in the most advanced industrial countries of Europe, which may be said to have introduced an entirely new element into Old World trade, we find other phases of commercial expansion which were quite as unexpected and are likely to profoundly affect our economic, and perhaps our political, future. The rapid growth of cotton manufacturing in our Southern States, for example, could not have been anticipated a few years ago, although it seemed probable to those familiar with the peculiar advantages of the South for engaging in this industry that some day that section would emerge from its position of dependence upon outside markets for the consumption of its cotton and create its own home markets by the erection of mills. Within the years 1889-1899, inclusive, according to Mr. A. B. Shepperson, of New York,* the number of spindles in the South increased 190½ per cent., against 11.4 in our Northern States, 4 1-3 per cent. in Great Britain, 30.6 per cent. in continental Europe, 71 per cent. in India. "In the percentage of increase of spindles and of consumption of cotton" (206½ per cent. in Southern and 29 per cent. in Northern mills), says Mr. Shepperson, "the South makes the best showing of the countries compared, while India is a good second."†

There are now nearly 4,000,000 spindles in the South, against 1,360,000 in 1889, and new mills are constantly being built,‡ although the past year has witnessed depression in the industry due to the troubles in China. The entrance of the South into oriental trade is almost as novel a feature of our expansion as any that have been indicated, and it is one that seems likely to have a most important bearing upon our social and political evolution, as well as upon our influence in international trade. The South has suddenly acquired a great stake in the affairs of the Far East, and what this may mean in the adjustment of our relations with other countries having large

* Cotton Facts, December, 1899.

† Increase of India in number of spindles, 71 per cent.; in consumption of cotton, 88½ per cent.

‡ "The current year," says Prof. Henry M. Wilson, of Raleigh, N. C., in an article in the 'Textile Manufacturers' Journal' of December 20, 1900, "has witnessed greater strides in cotton manufacturing in the South than last year, when the growth of the industry was considered phenomenal. New spindles and looms have been added, new mills built, and others projected at a rate that causes the careful observer of the South's progress to gaze with amazement upon such activity. Nowhere in the world is the interest being taken in cotton manufacturing as here in the South, where most of the staple is produced. From returns made to the New Orleans Cotton Exchange, the number of new spindles added this year in old mills, new mills and in mills under construction is 1,456,897. New looms added to these same mills number 27,613."

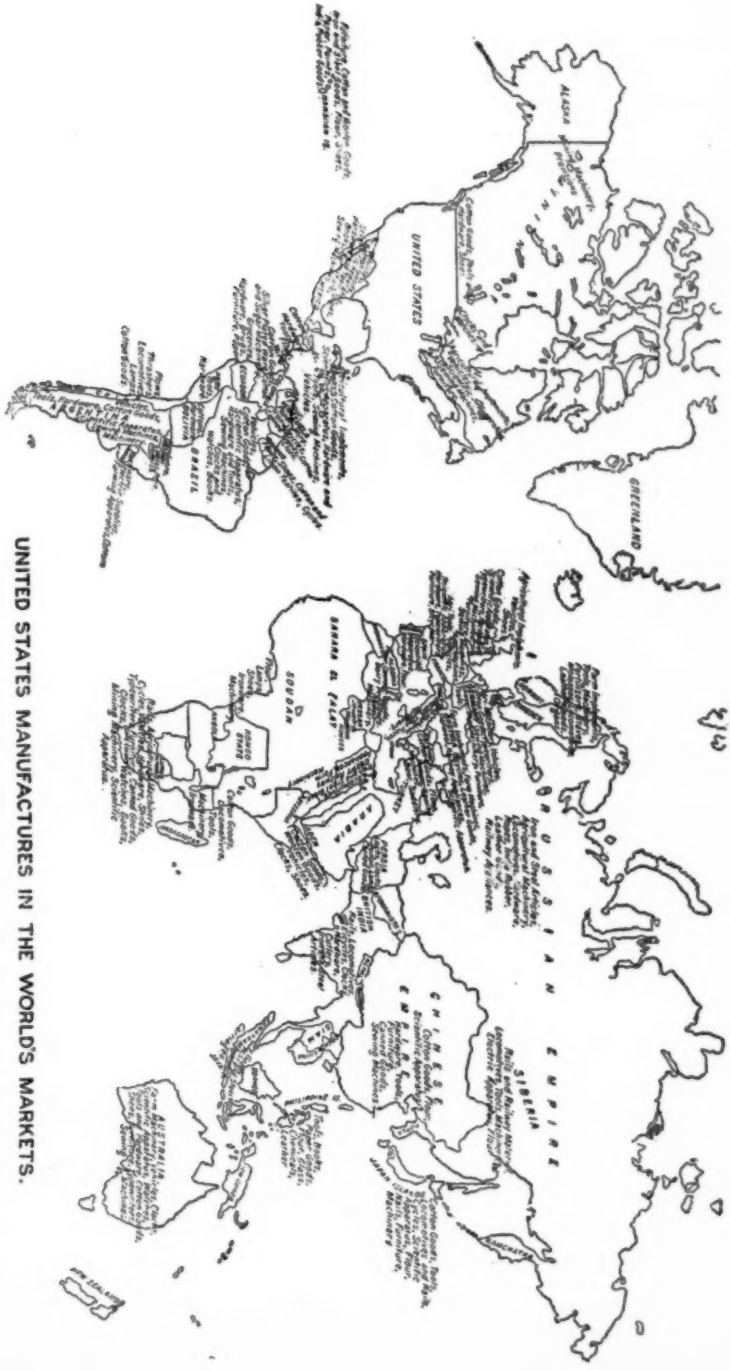
interests there and in shaping our international policies is a question which only the future can answer. In a memorial from the cotton manufacturers of the South addressed to the Secretary of State in November last, commending the 'open-door' policy in China, the statement is made that a large part of the production of the cotton drills and sheetings manufactured in Southern mills is exported to North China, and that "the prohibition or interference in China by any European government would tend to seriously injure, not only the cotton-manufacturing industries, but other important products of the United States which are being shipped to China. For the protection and perpetuity of these commercial relations," it is added, "we earnestly pray that the Administration will take such action as may be proper under existing conditions. It is not only the manufacturers of cotton goods that would be seriously affected, but the Southern planter and cotton grower, who finds a ready cash sale for his products at his very door; and also the thousands of employees and laboring classes who are engaged in the cotton mills and depend on the success of these manufacturing industries for a livelihood."

The developments of the past two years in consequence of our acquisition of the Hawaiian and Philippine islands have brought another factor into prominence in our commercial development, which may be potential of unlooked-for results. The Pacific slope is rapidly being converted from a mere outpost of trade into a great hive of commerce.* Not only San Francisco, but Port Townsend, Seattle, Tacoma and Portland, are becoming entrepôts of Oriental and South Pacific commerce, and San Diego seems likely to be an important factor in the development of trade with the west coast of Latin America.

The growth of sea-borne commerce at these points means much for the great extent of country tributary to them and promises to work marked changes in the industrial condition of the vast region west of the Rocky Mountains. In a similar way, our southern group of States may find a sweeping readjustment of their economic relation to the rest of the Union in the fact that Cuba and Porto Rico now offer them easy and convenient stepping stones to Latin American trade.

Even in the now familiar conditions affecting the Atlantic seaboard, which, as we have seen, have recently produced a great increase in our export trade, a new element appears in the statement of our consul in Sierra Leone, Mr. Williams, that, in a few years, West Africa will offer a market for our goods 'only second in importance

* Exports from ports on the Pacific coast (excluding Alaska) which amounted to some $36,800,000 in the fiscal year 1895, rose to $75,300,000 in 1898, and, though the total fell to $57,600,000 in 1899, it rose again to $71,600,000 in 1900 (years ended June 30).



UNITED STATES MANUFACTURES IN THE WORLD'S MARKETS.

to that of China.' East Africa and South Africa have already shown a marked preference for certain lines of American manufactures, but West Africa is for our exporters a new and more accessible market, the possibilities of which have heretofore attracted but little attention.

DISTRIBUTION OF OUR EXPORTS.

A glance at the accompanying map of the world, showing the distribution of our exports of manufactures, reveals the significant fact that, as yet, the widest range of consumption of our goods is found in the leading industrial countries, such as Great Britain, Germany, France, and their willingness conjoined with their greater capacity to take our products raises the interesting question whether our activity in competing for neutral markets, such as China, Africa, South America, etc., is not, for the present, restrained by the fact that our energies are largely employed in manufacturing for the European demand. The seriousness of our competition in the development of trade in countries which, as yet, are but imperfectly exploited will begin to be fully felt, it would seem, only when the European demand shall have slackened or we shall have more than met its requirements. In that case, our exporters would undoubtedly address themselves more systematically and with greater energy to trade regions which our European rivals are now so industriously seeking to control. There is food for thought also in the possible consequences to our European trade of a rivalry on our part which may be so crushing as to greatly impair the purchasing power of those who are now our best customers. If we permanently cripple their chief industries, we deprive them, to a greater or less extent, of the means of buying from us, and the consumption of our food supplies and our raw materials, as well as of our finished goods, may be greatly curtailed. The solution of the problem may perhaps be found in the gradual specialization of commerce and industry, according to the peculiar capacity of each competing nation—the survival, in other words, of the fittest conditions for this or that country—and the gradual subsidence of competition into healthful exchange.

THE PLANET EROS.

By Professor SOLON I. BAILEY,
HARVARD COLLEGE OBSERVATORY.

EROS is the name of a small planet discovered in 1898, by Witt, of Berlin. It does not appear to be altogether certain that it really belongs to the group of minor planets, usually known as planetoids or asteroids. With the exception of Eros, all known asteroids move in orbits whose mean distances are greater than that of Mars and less than that of Jupiter. The mean distance from the sun of Mars is 141 million miles, and that of Jupiter is 483 million miles, while the distances of the asteroids vary in round numbers between 200 and 400 million miles. The mean distance of Eros, however, is only 135 million miles, which is less than that of Mars. In spite of this very important difference, Eros has been placed among the great band of asteroids, among whom he numbers 433. To belong to the celestial 400 is perhaps more of misfortune than of honor, for the number of this plebeian band has already waxed so great that they have become a care which threatens in the future to balance the benefits which they bring to astronomy. Nevertheless, the history of this numerous family is sufficiently full of interest, and throws light upon the way in which we should regard them.

In 1772, Bode announced the so-called law which bears his name. The law may be stated as follows: If to a series of 4's, beginning at the second, the numbers 3, 6, 12, 24, etc., be added, the resulting numbers divided by 10 will approximately express the distance of the planets from the sun in terms of the distance of our earth taken as unity. The law gave fairly well the distances of all the planets known at that time, except that it called for a planet between Mars and Jupiter, where nothing was then known to exist. When, a few years later, in 1784, Uranus was discovered and was found to conform closely to the law, the impression was deepened that the missing member of the solar system must somehow be supplied or explained, and an association of astronomers was formed to hunt for it. At that time the discovery of a small body, such as one of the asteroids, was no easy matter, and the honor of finding the first did not fall to one of the associates, but to Piazzi, a Sicilian astronomer, who discovered it while making a star catalogue. It was perhaps fitting that a century which was to be signalized by the discovery of some 450 new but small worlds, where one had been sought, should be properly

opened: Ceres, the first asteroid, was found on the first day of the nineteenth century. Bode's law, therefore, appeared to have found confirmation here, for, though there was no single great planet, as elsewhere, nevertheless the small army of fragments seemed to point to some abortive attempt of Nature to form a world in the usual order, or else to an explosion of one already formed. In either case the distance of the 'mean asteroid' might be expected to follow the law, which it was found approximately to do. It seems a pity that the law, having survived so many tests, should go to pieces at last on what was perhaps the final test which remained to be applied. When Neptune was discovered, however, in 1846, it did not conform to the law at all. The following table gives a comparison between the true distances and those which result from Bode's law, the distance of the earth being taken as unity:

Planet.	Distance.	Bode.	Difference.	Period.
Mercury	0.39	0.4	—0.01	3 months.
Venus	0.72	0.7	+0.02	7.4 "
Earth	1.00	1.0	0.00	1.0 years.
Mars	1.52	1.6	—0.08	1.9 "
Mean Asteroid	2.65	2.8	—1.15	....
Jupiter	5.20	5.2	0.00	11 9 years.
Saturn	9.54	10.0	—0.46	29.5 "
Uranus	19.18	19.6	—0.42	84.0 "
Neptune	30.05	38.8	—8.75	164.8 "

The discovery of asteroids has been much simplified by the increase of star maps, and especially by the advances in celestial photography. One feature, which is incidental to the duration of the photographic exposure, renders the detection of such objects comparatively easy. When a photographic plate is exposed to the sky in a camera or telescope, if there is no clockwork, so that the instrument remains at rest, the images of the stars are drawn out into lines or trails. Ordinarily, however, the instrument is kept in motion by a driving clock, so that it exactly follows the stars in their apparent daily motion, and the images of the stars result as circular dots on the plate. An asteroid, however, from its nearness has so rapid an apparent motion among the stars that, if an exposure is made of an hour or more, its image is spread out in a line, while the images of stars remain circular. On some of the plates, for example, made with the great Bruce photographic telescope at Arequipa, several hundred thousand stars appear. On one of these plates, which had an exposure of four hours, seven asteroid trails were found. If these asteroids had formed circular images, similar to those of the stars, their detection among the several hundred thousand images on the plate would have been an enormous labor and would have required other

photographs of the same region for comparison. To pick out the trails, however, is the work of an hour. The finding of the images on the photographs is only a small part of the work involved. First, one must know whether the object seen is new or old. This implies tables giving the positions of all known asteroids, the computation of which involves a great amount of labor, and, in most cases, the results in themselves seem to be of small value. With the greater telescopes and more sensitive plates of the future, it seems probable, unless some kind Providence prevents it, that the number will become so great that astronomers will grow weary of the enormous labor involved in making ephemerides of them all. Twenty-two of them are, as Professor Young expresses it, 'endowed.' These were discovered by Professor Watson, who, at his death, left a fund to bear the expense of taking care of them. These favored ones will evidently be followed carefully, however unobserved their less aristocratic sisters go sweeping on in their neglected orbits.

It is probable that all the larger asteroids have already been found. Professor Barnard has made many micrometric measurements of the diameters of the largest of these baby worlds, using the great telescopes of the Lick and Yerkes observatories. He has recently published in the 'Monthly Notices' of the Royal Astronomical Society the following results:

Asteroid.	Diameter.	Albedo.
Ceres	477 miles.	0.67
Pallas	304 "	0.88
Juno	120 "	1.67
Vesta	239 "	2.77

The albedo, or light-reflecting power, is referred to that of Mars as unity. The values in the third column are derived from the measured diameters and the known brightness of the asteroids. Vesta, though not the largest by the above measures, is the brightest of them all, and is sometimes visible to the naked eye. Probably none, except the four given above, has a diameter as great as 100 miles, and the vast majority perhaps not more than ten or twenty miles. Eros itself, at its nearest approach, will perhaps present a disc of sufficient size to permit measurements in the most powerful instruments. Its diameter is probably not more than twenty-five miles, though no precise determination has yet been made. On such a world the force of superficial gravity would be about one three-hundredth of that at the surface of the earth, and a person might almost throw a stone with sufficient velocity to make it fly off into space and become an independent planet. To

make up a world even one-hundredth as large as the earth would take hundreds of thousands of such worlds.

On the night of August 13, 1898, Herr Witt made a photograph of the region near β Aquarii, with an exposure of two hours. He wished to obtain an observation of a known asteroid which had not been observed for nine years, and which his calculations assigned to that region. When developed and examined on the following day, the plate not only showed the object desired, and also a second known asteroid, but a faint and long trail of some unknown object. From its rapid motion it was at first thought to be a comet, but an examination on the following night with a visual telescope revealed its true nature. As soon as the well-known computer of minor planet orbits, Herr Berberich, had computed its approximate orbit, the astonishing nature of the new planet became apparent. Of all the previously known members of the solar system, with the obvious exception of our moon, Venus and Mars approach nearest to the earth. Venus is distant from us at the most favorable times about twenty-five million miles, and Mars thirty-five million miles. Eros, however, approaches the earth at the most favorable oppositions within less than fourteen million miles, so that he is our nearest celestial neighbor. This leads to a solution, under better conditions perhaps than ever before granted, of that fundamental problem in astronomy, the distance of the sun, or, in other words, the determination of the solar parallax. In order to determine the orbit and position of a planet, certain quantities must be found, based upon at least three observations of the planet's place in the sky. It is, however, highly desirable to have more than three observations of the planet's position and to have them widely separated in time.

The following elements for Eros were computed by Dr. S. C. Chandler, and were based on the observations of 1898, combined with those of the Harvard photographs made in the years 1893, 1894 and 1896:

EPOCH 1898, AUGUST 31.5, GREENWICH MEAN TIME.

Mean Anomaly	221°	35′	45.″6	
Perihelion Distance of Ascending Node	177	37	56. 0	1898.0
Longitude of Ascending Node	303	31	57. 1	
Inclination of Orbit to Ecliptic	10	50	11. 8	
Angle whose Sin is the Eccentricity	12	52	9. 8	
Mean Daily Motion	2015.″2326			
Logarithm of Semi-major Axis	0.1637876			
Period of Revolution around Sun	643^d.10			

Later observations will doubtless slightly modify these results, but they are sufficiently precise for our purpose. These elements were published in December, 1898, and well illustrate the enormous photographic resources which at the present time are in the possession of the Harvard Observatory. Twenty years ago, the present Director,

Prof. Edward C. Pickering, began photographing the heavens, and at the present time there are in the Observatory more than 100,000 photographs of the sky made during those years. Some of these are on a large scale, and are of special objects, but many thousands of them are charts on so small a scale that the entire sky has been photographed many times. On nearly all these plates stars are shown to the tenth magnitude, and in many cases stars as faint as the fifteenth or sixteenth magnitude appear. The early elements of Eros showed that the planet made a close approach to the earth in 1894, and a search was promptly instituted on the Harvard photographs. At first the available observations were insufficient to give the elements with the accuracy which was necessary in order to determine the planet's

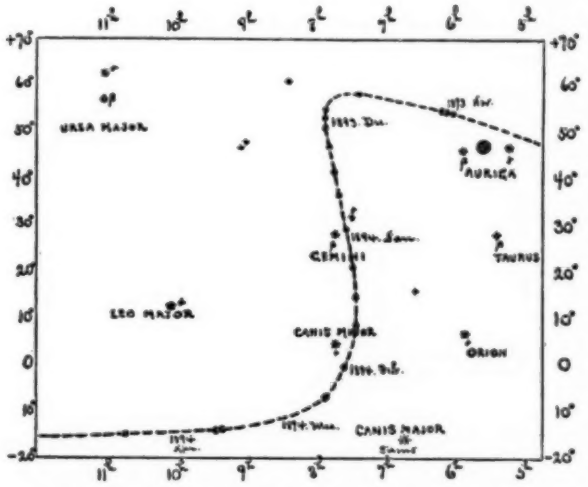


FIG. 1. PATH OF EROS IN 1893 AND 1894. THE CIRCULAR DOTS REPRESENT THE POSITIONS WHICH WERE DETERMINED FROM THE HARVARD PHOTOGRAPHS.

position in 1894. An error of 1″ in the mean daily motion would change the right ascension in 1894 by about half an hour. On this account no image of the planet was found on the photographs first examined. By an examination, however, of plates made in 1896 Mrs. Fleming found several images of Eros, and Mr. Chandler then provided a corrected ephemeris, by means of which the planet was readily found on plates made in 1893 and 1894. Thus several years' history of this remarkable object was at once presented to the astronomical world.

While the mean distance of Eros is 135 million miles, its aphelion distance is 166 millions and its perihelion distance 105 millions. Since this planet is sometimes within and sometimes without the orbit of Mars, it might be expected that at favorable times it would approach

nearer to Mars than to the earth. Owing to the large inclination of the planes of the two planets, and the unfavorable position of the line in which the planes intersect, this is not the case, as was pointed out by Mr. Crommelin. Eros does not approach Mars nearer than twenty million miles, so that the Martians, if such exist, have no advantage in this line of research.

At his approach in 1894, the brightness of Eros was computed by Professor Pickering to have been about the seventh magnitude. This places it just beyond the reach of the naked eye, even at the most favorable oppositions. During the recent opposition Eros was thirty million miles distant, and fainter than the ninth magnitude.

E. von Oppolzer has recently announced that Eros undergoes, within a few hours, variations in light amounting to a whole magni-

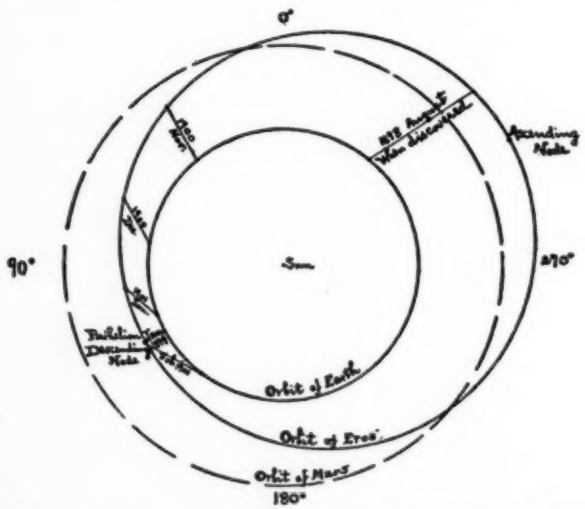


FIG. 2. ORBITS OF EROS, EARTH AND MARS. RELATIVE POSITIONS OF EROS AND EARTH.

tude. This variation has been confirmed at the Harvard Observatory, where there are observations, visual and photographic, extending back over eight years, sufficient to establish the period with precision. The variability of Eros is doubtless due to its axial revolution, and may be caused by the unequal light-reflecting power of different parts of its surface.

From the elements and diagram, it may be seen that the distance from perihelion, or the point nearest the sun, to the descending node, or the point where the planet passes through the plane of the earth's orbit, is less than three degrees. This is fortunate, for otherwise the planet's distance would be increased. The longitude of the planet's perihelion is 121°. The earth's longitude—or the sun's longitude, as seen from the earth, plus 180°—is 121° on January 21. In 1894, the

planet was in perihelion on January 22, only a few hours later than the earth arrived at the same longitude; so that the opposition at that time was nearly as favorable as can ever occur. Since the period of Eros is $643^d.10$, it will be easy to compute when the planet will again come to perihelion near the date January 21. The relation between the periods of Eros and the earth is such that a close approach will always be followed in seven years by one not so good, but yet favorable. This is illustrated by the near approach of 1894 and the less favorable opposition of 1901. Seven revolutions of the earth take $2556^d.8$, and four revolutions of Eros, $2572^d.4$. Hence every seventh year the position of Eros will be repeated, with respect to the earth, within 156^d. So that if Eros arrived at perihelion one day later than the earth reached the same longitude in 1894, it would arrive there about seventeen days later in 1901, thirty-two days later in 1908, etc. It is evident that by following this series no close approach would come again till far into the next century. This series includes one-fourth of the perihelion returns of Eros. Three other series will include the remainder. They may be reckoned from that of 1895, when it occurred eighty-seven days earlier than the earth reached the same longitude, that of 1897, 175 days earlier, and that of 1899, 262 days earlier. Beginning with the difference of eighty-seven days in 1895, the number decreases by $15^d.6$ every seven years, so that in 1931 Eros will arrive at perihelion about ten days ahead of the earth, and in 1938 about six days later. This pair of oppositions appear to be the best which will occur during the next half century. The series which begins in 1897 with a difference of 175 days would apparently give a close approach after about three quarters of a century, and the remaining series much later still. It seems, therefore, that not till the latter part of the present century can so favorable an opposition recur, as that of 1894, which was lost except for the Harvard photographs. These conclusions may, however, be modified by a study of the perturbations of Eros by the other planets, which have not been considered in the above computations.

During the last few months great attention has been given to Eros at fifty of the leading observatories of the world. Professor Campbell, Director of the Lick Observatory, says that for two or three months fully half the resources of that institution have been devoted to this object. The positions of 700 fundamental stars have been determined by the meridian circle, and photographs made, which will be measured at the Observatory of Columbia University under the direction of Dr. Rees. At the Harvard Observatory several hundred photographs have been taken, and very extended photometric observations made. Owing to the exceptional conditions which prevail at the Arequipa branch of the observatory and the power of the Bruce pho-

tographic telescope, it is probable that Eros can be photographed there after it has been lost sight of at other observatories. At least, the first determination of its position at the recent opposition was made from a photograph obtained there by Dr. Stewart. The interest shown by these two institutions is equaled by that of many other observatories in Europe and the United States. The chief object of these labors is the determination of the solar parallax, which is the angle subtended at the sun by the earth's radius, and which is a measure of his distance. The methods which are in use for the solution of this problem may be divided into three groups, geometrical, gravitational and physical. The present investigation belongs to the first of these. The natural and direct method for measuring the sun's distance would be to select two stations on the earth, whose distance apart must be known, and from them measure the angle which that distance subtends at the sun itself. If the distance is the earth's radius the measured angle is the solar parallax. In fact, however, this apparently easy and direct method has now no value whatever, since the angle concerned is too small to give the best results, and also the sun is a very difficult object on which to make measurements of precision. Some other, nearer and more suitable object must be sought, and, in quest of the most exact results possible, astronomers have observed Venus, when in transit across the sun's face, Mars near opposition and various asteroids. Of these different geometrical methods, observations of the asteroids appear to have furnished the best results, so that the discovery of Eros comes at a most fortunate time to give astronomers an opportunity of testing this method under the most favorable conditions. It must be remembered, however, that the recent opposition of Eros was not an especially favorable one, and it is not certain that better results will be obtained at this time than have been secured in recent years by Dr. Gill at the Cape of Good Hope, in cooperation with Dr. Elkins, of Yale, and others. That work depended upon heliometric observations of the asteroids Iris, Victoria and Sappho, whose least distances from the earth are 0.84, 0.82 and 0.84 astronomical units. At the recent opposition the distance of Eros was little more than a third as great, and this in itself gives Eros an enormous advantage. It has been feared, however, that the faintness and rapid motion of Eros would prevent observations of the highest precision, which might be sufficient to balance the advantage which its nearness gave. Probably the difficulties on these accounts have not proved so great as was at first feared. Even if the present determination yields no better results than have been obtained before, it will make a very valuable check on previous determinations, and bring out the best methods to be pursued at some later and more favorable opposition. In this connection it may be of interest to recall that Halley, who first pointed out the

possibility of determining the solar parallax by observations of the transits of Venus, well knew when he developed the methods that he himself could not live to see the experiment tried, since he was then sixty-three years of age, and the next transit of Venus did not come for forty-two years. Perhaps few of the observers who are so enthusiastically at work on Eros at this opposition will be alive to make observations at a really close approach of that interesting body.

At the Paris meeting of the International Astrophotographic Congress, in August, 1900, a committee was appointed to suggest the most favorable course to be pursued. The committee later advised that work be done by the micrometer, the heliometer and by photographs. The observations in each case give the distance of Eros in seconds of arc from adjacent stars. The simplest case is where simultaneous observations are made by observers at widely separated stations. Let A and B (Fig. 3) be two stations on the earth. The observer at A will see Eros projected on the celestial sphere at E^1, and the observer at B, at

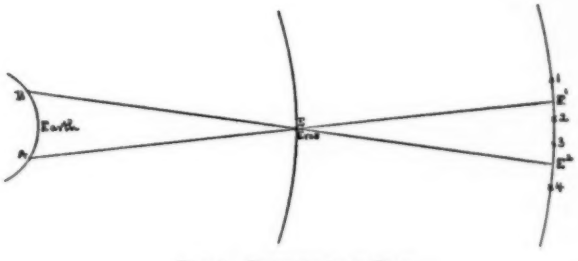


FIG. 3. PARALLAX OF EROS.

E^2. It is only necessary for each observer to measure the distance in seconds of arc between Eros and some adjacent stars, as 1, 2, 3 and 4. The positions of the stars must be known with the greatest precision, so that the observations give the value of the arc E^1E^2, which equals the angle AEB. We have then the necessary material for computing the distance of Eros from the earth in miles. Given this and the orbit of Eros, the distances of the earth and all the other planets from the sun in miles follow from the known laws of gravitation. The distance AB may lie in a north and south direction, or in an east and west direction, or more probably in a combination of the two. In the first case there must be two observers, widely separated, as, for example, at Arequipa, Peru, latitude south 16°, and Helsingfors, Finland, north 50°. In the second case there may be two stations, as, one in Europe and the other in the United States, or the whole work may be done at one station by allowing the earth's diurnal motion to carry the observer to a new position. Suppose, for example, that one observation is made when the planet is rising in the

east, and another twelve hours later, when it is about to set in the west. In the meantime, the observer will have been carried to a position 8,000 miles removed from that which he occupied in the morning. Each of the three methods has certain objections and difficulties. Simultaneous observations are difficult or impossible to obtain. Between the different observations both earth and Eros are sweeping along in their orbits, and this introduces complications which must be allowed for with great care. Also the size of the earth is not perfectly known, nor the distance apart of any two stations upon its surface, though the error introduced from this cause is very small.

For the determination of the position of Eros on each day during opposition, as recommended by the Paris committee, the precise positions of very many stars must be known. A few of these have already been determined, but most of them must be measured at the present time. For this purpose the positions of several hundred stars will be determined and the highest precision at different observatories with the meridian circle, and, from these as standards, many hundreds more, by photographs. For the positions of Eros itself with relation to these stars, no doubt the micrometer, the heliometer and the photograph will be used, and a comparison of the results by these three instruments will be of the greatest interest.

Observations of Eros, made during the recent opposition, or in the future, will doubtless give the most exact determination of the solar parallax possible by the geometrical method, applied to any known member of the solar system. Indeed, Eros, at the most favorable times, is perhaps as good an object as can be desired. If it came still nearer to the earth, its motion would doubtless be more rapid, so that little would be gained. According to Professor Newcomb, Eros comes 'about as near to us as observations can advantageously be made.' Nevertheless, it is doubtful whether any geometrical determination of the solar parallax will ever be accepted as final. When the astronomical world was preparing to observe the transit of Venus in 1874, Leverrier refused to take any part in it, declaring that the determination by gravitational means would make all geometrical methods of no further value. This may be true for the future, but it will not lessen, for the present, at least, the high value of the determinations now going on.

The solar parallax is about 8″.80, correct within approximately 0″.01. That is, the distance of the sun is about 92,897,000 miles, correct within 100,000 or 150,000 miles. It is difficult to appreciate an angle of 0″.01, within which limit the determination must come to be of value. A foot rule forms an angle of 0″.01, when placed at a distance of 20,626,481 feet, or over 3,900 miles. If the present work shall reduce the margin of doubt, astronomers will be well paid for their efforts.

Aside from the determination of the solar parallax, Professor Pickering has pointed out that Eros furnishes an opportunity for the investigation of several interesting photometric problems. These are: the determination of the planet's diameter; a test of the law that the light varies inversely as the square of the distance; a test of the existence of an absorbing medium within the solar system, and a test of the law connecting the phase angle of a planet with the variation in brightness.

Thus Eros, the tiny asteroid, whose total area is little larger than the State of Rhode Island, is for the moment of more importance in the eyes of the astronomical world than the greatest planet which moves about the sun.

DISCUSSION AND CORRESPONDENCE.

WHAT THE UNIVERSITY OF CHICAGO STANDS FOR.

AT the time of Princeton's celebration in 1896, one of her loyal alumni undertook to show what Princeton has stood for and stands for. "The name Princeton," he remarked, "is supposed to be synonymous with the stiffest intellectual conservatism." The philosophical temper dominates at Princeton, just as the literary spirit characterizes Harvard. If the question be asked, What the University of Chicago stands for? one may answer without hesitation, *for the scientific method!*

The scientific cast of mind is ascendent in the halls and laboratories of this new university of the West; or, at least, one may affirm that it is becoming so. It is due in part to the presence of so many specialists who have received their professional training in Germany and have brought back something of the German scholar's aptitude for investigative work.

Even in the Divinity School the influence of the scientific spirit is felt by both teachers and students. In the work of advanced students, as in the departments of physical science, the paramount idea or aim is the acquisition of a method by which truth may be found, and they are characterized by a willingness to go wherever truth may lead them. Theology is not the fixed thing that it was formerly imagined to be. The professed aim of the Department of Systematic Theology is "to reduce to a scientific system, and maintain on scientific principles, the teaching of Scripture in the light of such other sources of theological knowledge as enter into the progressive self-revelation of God to mankind." Mysticism is at a discount in Dr. Northrup's classrooms.

Of scholastic traditions Chicago has none as yet, but it has a certain definite purpose or policy distinct from that of the old college. The University of Chicago stands for another educational ideal.

The old college aimed to give the student a liberal education, as it is called, a wider mental horizon. Intellectual discipline was emphasized. Some good results were attained, for the man who took the four years' course was unquestionably benefited by the process. There were, however, some defects in the system. While the culture of the old college tended to make his thinking more clear-cut and logical, it did not go far enough, in that no postgraduate work was provided. Its alumni went forth into the world and, after three years of professional employment, they received the degree of A. M., without further study or even an examination.

The humanities are not neglected at the new University of Chicago—their disciplinary value is recognized and prized; but at the same time research is emphasized, and advanced students are encouraged and assisted to engage in original investigation. To enlarge the borders of knowledge is the end in view. The way chosen is through specialization. In chemistry, candidates for the much-coveted degree of Ph.D. must take two or three years of laboratory work under the supervision of a university instructor; and the thesis, embodying the results of their researches, 'must be a real contribution to knowledge.' A few sentences describing the work in geology may be quoted:

"The aim of this department is to provide systematic training in geology. . . . The endeavor is to furnish this training in such a form as to contribute to a liberal education, and at the same time to prepare for professional and investigative work in the science. The

cultural purpose predominates in the earlier courses, and the investigative and professional in the later; but both have a place in all and find their realization in a common method of treatment. While it is not expected that more than a small percentage of those who take the earlier courses will have professional or investigative work in view, it is believed that they will derive the largest and most distinctive returns from such shaping of the work. That special mental and moral discipline which is appropriate to the science can be secured only by wrestling with its problems as they actually present themselves to the investigator. A radically different discipline is secured from handling the subject in the simple didactic method. It is believed that those who enter upon any of the courses with an intelligent appreciation of the science as a growing body of truth and a progressive field of intellectual endeavor will desire to come into touch with its working methods and controlling spirit."

In his address before the Baptist Social Union of Chicago, Nov. 5, 1891, Dr. W. R. Harper set forth what might be expected of the new University of Chicago. Much has been accomplished along the lines indicated. Two or three passages in this notable utterance are worth repeating:

"In these days of specialists, the man who has passed through college has, after all, but a smattering of things. Possibly before his course is completed, and certainly at the close of it, he should have a chance to take some special subject and give it the continuous attention of months. Concentration on a given line, before graduation, should be encouraged. . . . The college-system, as we all understand it, is not intended primarily to stock the pupil's mind with knowledge, but rather to develop it, to make it able to receive and apply truth from every source; in brief, *to open* the mind. . . . But it is not sufficient simply to be open to accept truth when it presents itself; to adopt new or modified methods, when they have been suggested by others. A university may not stop with this. Shall you not expect contributions, and these not small ones, to the sum of human knowledge? Shall you not expect a spirit pervading every department of the university life which will lead men from the lowest to the highest department *to investigate and to experiment?* A deal of truth, known for ages, if it is to exert any influence to-day, must be restated. Such restatement makes it practically new truth, and the contribution of the man who has done this is only less than that of him who first formulated it. Old forms of statement in every line of work have lost their force; they have been worn smooth, till now they are really valueless."

Hence the need, not only of specialists and laboratories, but of an endowed University Press for the publication of books and periodicals. This want has been supplied by the admirably edited journals of the University, which contain articles summing up the results of studies and experiments pursued in numerous lines of intellectual activity. Usually the head professor of the department is the editor, aided by his associates and by eminent scholars in other universities of America and Europe. It is not necessary to dwell on the merits of the 'Botanical Gazette,' the 'Journal of Geology,' the 'Journal of Political Economy' and the other monthlies and quarterlies issued from the University of Chicago Press. The value of this series is appreciated, and their success is a credit to American scholarship.

The keynote of the university spirit is devotion to the cause of truth for its own sake. This mental attitude was well described in Professor Chamberlin's convocation address (April 1, 1893) on 'The Mission of the Scientific Spirit':

"Simple observation is incapable of disentangling intricate phenomena and of discriminating with precision the several agencies and their varying results. Even when it discerns the agencies, the complexity of the combination baffles all efforts to evaluate the measure and degree of participation. In the varying degrees of participation of causes lies the greatest peril to safe conclusions.

"But by the devices of experimentation, each factor may be disentangled from its complex associations and made to reveal itself in its simple and naked reality. Experimentation, by its creative processes, opens a new world of observation; a world devised and controlled solely for the disentanglement of truth. The new potency thus added to observation and induction gave birth to modern science. By its aid the mass of crude facts previously gathered were

purified and perfected and increased by manifold additions. Upon this relatively pure, solid truth a trustworthy superstructure was built by the inductive method. But even the inductive method, potential as it is, would have fallen short of trustworthy results, were it not furnished with facts verified by searching experimental tests."

The investigator must be a lover not only of the truth, but of 'the pure and exact truth.' Hence the necessity for the scientific method, which may be defined in brief as a process for the purification of truth from error. A fuller statement is given by Sir William Turner in his address before the British Association in 1900:

"Scientific method consists, therefore, in close observation, frequently repeated, so as to eliminate the possibility of erroneous seeing; in experiments checked and controlled in every direction in which fallacies might arise; in continuous reflection on the appearances and phenomena observed, and in logically reasoning out their meaning and the conclusions to be drawn from them."

The scientific method, then, is something more than diligence and accuracy. It is not suddenly acquired. It has been a slow growth in the race—a growth to which Aristotle, Euclid, Bacon, Galileo, Newton, Kant, Darwin and many others contributed. And it is a slow growth in the individual. Some persons of intellectual tastes never acquire it. The Oriental mind is weak in this direction. It is claimed that Americans have less of the scientific spirit than the Germans. The work of the old college did not tend to develop the scientific habit of mind in the student. Said Professor Remsen, in his convocation address (Oct. 2, 1894) on 'The Chemical Laboratory':

"If the experience of twenty-one years in teaching in college and university in this country is worth anything, your speaker, who has during that time had to deal with many students from all parts of the country, is justified in asserting that the minds of students who enter college are very far from being scientific, and the same can be said of most of them fresh from the colleges. By a scientific mind is meant one that tends to deal with questions objectively, to judge things on their merits, and that does not tend to prejudge every question by the aid of ideas formed independently of the things themselves."

Since the scientific spirit is not quickly and easily acquired, means are provided to foster its development. The laboratory is the especial place for experimentation in pure science. In other fields data must be sought elsewhere. In sociology it is the world of men and women. The student who tried working behind a counter in a big department store made a sociological experiment where she might learn by experience and observation the condition of clerks and cash-girls as she could not in the class-room.

The aim of the scholarly investigator is to reach results that can be expressed in some tangible shape or tabulated form, and his conclusions must be accompanied by the evidence on which they rest. There is too much of assumption in the thinking of the average student.

It has been said that "the one factor which has made the German university what it is to-day is its docent system." The docent system cannot be transplanted to our soil the same as it is in Germany. The conditions are different here. It is a factor, however, to be counted upon to foster scientific investigation among us.

Much, too, may be expected of the fellowship plan. It serves a useful purpose in affording exceptional opportunities to men possessed of the love of science and displaying proficiency in laboratory methods. The presence of a large body of fellows and scholars tends to raise the standard of intellectual work in general to a high grade of excellence. The offer of a substantial stipend is not without effect in stimulating effort. The fellowship is also in the nature of a stepping-stone to an instructorship—an inducement calculated to arouse the desire to excel.

Besides this incentive is another—that of environment, of association with an inspiring teacher and the companionship of skilled workers. "While it is

true," says Professor Nef, "to a great extent that the power of scientific investigation is inborn and not acquired, it is also certain that a proper atmosphere must exist for its development. It requires inspiration and example to kindle into flame the spark which may exist in men beginning their life-work."

The influences of departmental clubs, with their learned papers and discussions, is a factor making for critical scholarship. Another agency that promotes the acquisition of the scientific method is the Seminar. As it is only a recent growth in American universities, a fuller description of it is needed.

The professed aim of the Seminar is 'initiation into the methods of research.' To the scientist life presents itself as a series of problems, and these problems are to be grappled with and solved. The right way of attacking these problems the graduate student learns in the Seminar by contact with trained workers. He must get a first-hand acquaintance with his subject, whether literary, historical or scientific, by going to the sources. He must learn from instructors the recognized tests and principles of investigation and then apply them. He must learn to suspend judgment until full information is obtained.

Under the Seminar system the members meet once a week for a two-hours' session, usually Monday afternoons. The student works largely by himself, spending weeks or months gathering material for a report, which is subjected to criticism by other members of the Seminar and by the professor in charge. Thus he learns what defective work is. While patience and industry are necessary for the production of a satisfactory report, it is not enough 'to lead laborious days.' The subject must be treated in a scholarly manner; and, if possible, some new light thrown on it and old errors corrected.

The Latin Seminar may be taken as an illustration—*The Comparative Syntax of the Greek and Latin Verb*, under Professor Hale. The aim and plan of procedure are thus outlined for the autumn, winter and spring quarters of 1899-1900, two hours a week:

"The principal object of the Seminar will be the study of unsettled problems in the syntax of the Latin verb. In necessary connection with this object, however, a considerable amount of study will be given to the syntax of the Greek verb as it appears in the earliest Greek literature.

"Owing to the advanced character and difficulty of syntactical problems, the independent work of the members of the Seminar will not begin until after preliminary lectures and discussions have made clear the general attitudes and methods of various schools of workers in syntax in the past and present, and the fundamental principles that must now be recognized as properly governing investigation. Several books of Homer and plays of Plautus will next be read, with reference solely to the syntax of the verb. An analysis will then be made by each member of the Seminar of the treatment of the syntax of the verb in one of the more important grammars or treatises, after which he will devote himself to a special problem, or group of problems. A considerable amount of reading in the literature will be expected for the systematic and exhaustive collection of evidence in a definite field. Reports of the results of work upon special problems and of reading for the collection of materials will be presented from time to time at meetings of the Seminar."

So to produce scholarly workers in the various fields of learning is the function of the University—to train specialists, to make critics in the higher sense, to furnish investigators who will enter fresh fields and give the world the fruits of their researches. It is for this kind of work that the University of Chicago stands—not merely to impart what is already known, but to seek and find new knowledge. This is the province of a university as conceived by President Harper. It is a high ideal that he holds up: "The true university is the center of thought on every problem connected with human life and work, and the first obligation resting upon the individual members which compose it is that of research and investigation."

EUGENE PARSONS.

THE POPULATION OF THE UNITED STATES DURING THE NEXT TEN CENTURIES.

DR. H. S. PRITCHETT published in the November number of the POPULAR SCIENCE MONTHLY his estimate of the future population of the United States, based upon the past rates of increase. He found a comparatively simple equation which represented the census enumerations very closely, and, applying that to the future, he finds that the rate of increase, which was 32 per cent. per decade in 1790 and 24 in 1880, will be 13 in 1990, but will not have sunk to less than 3 for another thousand years and will not be zero for an indefinite time. He does not seem to have taken into consideration the density of population and what we might call the saturation point, or the maximum population which can be fed. A population far below its saturation point will increase rapidly, but when it saturates the land there is no increase, and as we approach our saturation point our rate will rapidly diminish to zero.

We do not know what our saturation point is under the present conditions of food production; but we produce far more than is needed for our twenty people per square mile. Nor can we estimate our future saturation point, for no one can presume to predict what science will enable us to do in the way of food production, other than what, by present methods, can be forced from the soil. We can only estimate our limit, basing it upon the known densities in countries which have always been populated to their limit.

The saturation point rises with civilization just as the saturation point of air for water rises with the temperature. Cultivated land is said to produce 1,600 times as much food as an equal area of hunting land. Denmark, for instance, could support but 500 paleolithic people, and when their culture rose to the level of the present Patagonians, 1,000 could exist, and 1,500 of those on the level of the natives of Hudson's Bay. In the pastoral stage each family requires 2,000 acres, and France could not support 50,000 of such people. For centuries after the Norman conquest the whole of Europe could not support 100 millions, or about 25 per square mile, while now there are 81.

When civilization is arrested, the saturation point remains stationary. China, for instance, is said to have had 400 millions for many centuries. When food can be imported and paid for by manufactured goods, the population can go beyond the saturation point. Great Britain, for instance, is said to import one-third of her food, and her 300 people per mile is supersaturation. When the countries from which she buys food are populated to the point that they have no surplus for sale, her population must decrease to the number she can feed, which is now 200 per mile. Should her factories fail through foreign competition, so that she cannot buy, she will also decrease in population, just as Ireland has done since the beginning of the last century, when England destroyed Irish industries to strengthen her own. English supersaturation is limited only by her power to buy and import.

America was saturated by savages in pre-Columbian times, and they were constantly at war for more room; but the land has always been far from saturation for civilized whites. Though we now export enough food for a large population, we cannot produce very much more, for all the useful land is now taken up. Fully 60 per cent. of the desert lands west of the 100th degree of longitude will never have water on it, and that alone will forever prevent us being as densely populated as Europe. Perhaps we can now support fully 125 millions, or 34 per mile, a point which Dr. Pritchett calculates we shall reach in 1925, at our present rate. By that time we shall have farms on 10 or 15 per cent. of the arid lands, the limit of possible irrigation, and perhaps then we can support 200 millions, the calculated population for 1950; but it is difficult to see how we can feed 500 millions, our

calculated numbers a little over a century hence, for that would be a density of about 125 per mile—far greater than Europe.

It is also difficult to see how science is to produce food indefinitely, for the real basis of food production is the soil and vegetation, such as the changing of cellulose into starches and sugars. The possible limit is the amount of the sun's energy we can capture through vegetation. The calculated population of a thousand years hence, 41 billions, or 11,000 per mile, is not at present conceivable.

There is a law of population, that its increase depends upon its density, irrespective of the birth rate; hence at the saturation point the death rate must equal the birth rate, as at present in China, where the large birth rate is compensated by frightful destruction of life, awful pestilences, famines, universal infanticide and judicial executions for every felony. Our civilization will never tolerate such mortality, nor can the surplus migrate, as it has been doing from Europe for four hundred years. Yet we need have no fear of future famines and pestilence due to overcrowding and so necessary in India and China, for the solution of the problem will come of its own accord in a natural limitation of the size of families by prevention of conception or some other means, a process already begun, as many have already pointed out. The average number of children in English families is already less than four. By the time we have reached our maximum growth it is quite likely that the number of children in American families will be less than three, or just enough to compensate for unavoidable deaths and still keep the population stationary. The deliberations of the Malthusian societies may appear very absurd, but they are merely discussing things which are sure to come about naturally and not artificially.

Thus Dr. Pritchett's estimates of our future population of 11,000 per square mile, being based upon the rates of increase in a country far below its saturation point, it seems that a better formula could have been obtained by taking the increases in European countries which probably have been saturated since the glacial times and supersaturated ever since they became maritime powers and could import food. Thus England had 5½ millions in 1650, and only 6½ millions in 1750, and less than 9 millions in 1800; since then, through food importations due to commerce, her rate of increase has been about 13 per cent. per decade. Our rate, as above stated, was 32 per cent. in 1800, 24 per cent. in 1880, and the time it will be 13 may be long before 1990, and it is quite likely to be zero within a century or two.

Our country will never contain more people than it can feed, and the struggle for existence or the stress of life will not be a particle more severe than now. Since the first paleolithic man appeared on the scene, Europe has supported as many men as she could and has thus been at the saturation point, ever on the verge of over-population, needing famines, wars of expansion and other forms of deaths, so that there has always been the same struggle for existence we see now, and that struggle can never be more severe than it has always been there. The course of civilization would even justify a prediction that life will be made easier, so that posterity may pity us as we pity our savage ancestors in their terrible struggle for existence.

CHAS. E. WOODRUFF, U. S. A.
Fort Riley, Kan., Jan. 30, 1901.

THE ORIGIN OF MEN OF GENIUS.

To the Editor: I have been much interested in Havelock Ellis's 'Study of British Genius,' for the reason that his conclusions are so nearly paralleled by a study of a like character for several of the continental countries reported by me in the latest number of the 'Conservative Review.' Mr. Ellis says, among other things: "When we survey the field of investigation I have here briefly summarized, the most strik-

ing fact we encounter is the extraordinary extent to which British men and women of genius have been produced by the highest and smallest social classes, and the minute part which has been played by the 'teeming masses' in building up British civilization. In the article above referred to it is shown that 'The nobility, the office-holding class and the liberal professions in no community form so much as a tenth part of the population, yet from this small minority seventy-eight per cent. of the primates of Italian and German literature, eighty per cent. of Spanish and sixty-nine per cent. of English were descended.' The fecundity of the different parts of French territory, like that of Great Britain, has been very unequal. "If we examine the nativity of French writers according to their geographical distribution . . . we find that the northern and eastern parts have been most prolific. (Is this the result of the comparatively large Teutonic intermixture?) Taking France by Provinces, Ile de France heads the list with 1,572 names out of a total of 5,617. Next in order comes Normandy with 413 names. The adjacent districts of Picardy and Artois furnish 373; Provence gives us a register of 295 names; Lorraine, 240; Touraine, Anjou and Maine, 207. All others fall below 200. Except in a general way, it cannot be known what relation these figures bear to the total population, as no census of France was taken until comparatively recent times. If we make an estimate on the present basis of inhabitants, the relation of the districts will be somewhat changed. Ile de France will still stand at the head, but the second place will be taken by French Switzerland, the third by Provence and the fourth by the Orleannais."

The religious milieu is a factor of very considerable importance. "It is well known that among French writers in all departments Geneva has produced a much larger proportion than would be expected from the number of its inhabitants. For more than four centuries it has been a Protestant city, while the rest of French territory has been for the most part Roman Catholic. It is worthy of remark, too, that in Germany, including by this designation its territory linguistically and not politically, the Catholic portions of Bavaria and Austria have given birth to a relatively small number of persons who are entitled to the highest rank in letters. It has already been shown that, in the product of men of science, the religion of a country seems to play an important part. We are justified in drawing the same inference in regard to literature."

One more quotation that bears on the preponderating influence of what may be called *centers of civilization*, and I have done: "Of fifty-five eminent Italian *literati*, twenty-three were born in large cities, and most of the remainder in small municipalities, though, strange to say, not one had Rome as his birthplace. Of the fifty Spaniards who are generally regarded as holding the highest rank in the literature of Spain, sixteen were born in Madrid, and a large proportion of the remainder in cities of the first rank, several of which contain universities. The *coryphei* of German literature seem at first sight to make an exception to the conclusions that naturally spring from the above-stated facts. The great writers are quite evenly distributed over what now constitutes the empire and Switzerland. Three large cities are the birthplace of three great writers each; two, of two each; while the rest have produced but one each. This calculation embraces about thirty who stand confessedly at the head; yet if we increase the number the results are not widely different. Here again the importance of the environment is strikingly made prominent. During the last five centuries Germany has had a large number of capitals, many of which the reigning monarchs tried with more or less success to make centers of art and literature."

CHAS. W. SUPER.

Athens, O.

SCIENTIFIC LITERATURE.

KANT AND THE NEBULAR HYPOTHESIS.

PROFESSOR HASTIE, of Glasgow, has added to his long list of editions and translations a book which he calls 'Kant's Cosmogony' (Macmillan). It forms a substantial addition to our knowledge in two distinct fields. In the first place, on the philosophical side, it throws important light upon some early phases of Kant's thought and upon the problems he was revolving years before he began the critical philosophy. In the second place, it contains a most interesting and, in many respects, valuable apparatus dealing with a chapter in the history of the interaction between scientific investigation and metaphysical speculation. Dr. Hastie's translation of Kant's 'Universal Natural History and Theory of the Heavens' forms the main central portion of the book. Around this he has grouped other material, making a most convenient collection. His own introduction contains an account of the status of Kant's nebular hypothesis, of its place in the lifework of this thinker, of its relation to other cosmogonies, of its later influence and fortunes, and the like, while he has added appendices affording useful sidelights on the whole discussion. In one of these, Thomas Wright, of Durham, a forgotten English physicist, is conclusively proved to be, so far as our present knowledge goes, the forerunner of Kant and the other writers, to whom we owe the first adumbrations of the view now generally accepted regarding the ultimate nature of the physical universe. A portrait of this worthy is reproduced. Dr. Hastie shows, too, how Kant was a forerunner of Darwin. And in this connection, though not directly, he hints the great difference in standpoint between the static science of the eighteenth, and the dynamic science of the nineteenth, century. "Give me matter and I will build a world out of it. Can we truly claim such a vantage ground in speaking of the least plant or insect? Must we not here stop at the first step, from our ignorance of the real inner constitution of the object? The structure of plants and animals exhibits an adaptation for which the universal and necessary laws of nature are insufficient." So Kant wrote, from the static standpoint. But his own view, all unknown to him, already involved dynamic categories. For its scholarship in the history of thought, for its clear knowledge of the scope and meaning of scientific advance, and for its eminent fairness of spirit, this book is to be strongly commended. The volume is dedicated to Lord Kelvin, as one of the men of science who have done full justice to Kant's attainments in the domain of 'the astronomical view of the universe.'

KNOWLEDGE AND BELIEF.

JUDGING from the author's remarks in his preface, Mr. F. S. Turner's 'Knowledge, Belief and Certitude' (Macmillan) has long been in preparation. As a result the argument is clearly stated, the various points following upon one another consecutively. The book furnishes a typical specimen of English philosophical writing. Indulging in no flights of speculation, the writer keeps firm grasp on what he sees, and so is able to give an account of himself which any intelligent reader can master. In fact, his book commends itself as a serviceable introduction to the problems with which science and philosophy deal. It is divided into two 'Books.' The first considers 'Abstract Knowledge.' Under this head consciousness is distinguished

from knowledge; and on analysis, the latter is found to possess three fundamental 'certitudes': self, other selves and the external world. Science comes under review next, and a most interesting and, in the main, sensible, account is given of its nature, as of its self-imposed limitations. This fills about 180 pages. Modern psychology is next brought to book. Here Mr. Turner cannot be said to achieve the same success. He makes certain good points. For example, he proposes the question, 'In what is called physiological psychology, what share of the discoveries belong to psychology proper?' In replying he shows that, ultimately, a very narrow line separates psychology from philosophy—a truth which some recent developments in psychology make patent. We do not think that in his chapter on 'Psychological Analysis' Mr. Turner preserves his customary reserve and balance. This appears plainly in the portion devoted to Wundt, where sympathy with the historical position of this psychologist lacks decidedly. The First Book, which is much the longer, concludes with a review of philosophy. Here the author manages to say some fresh and pertinent things: "Philosophy is necessary monistic. If philosophical speculation leads to dualistic conclusions, these really conduct to the sceptical conclusion—that the problem is insoluble." He infers that philosophy has no better or higher 'Knowledge' than the sciences. In this connection, his treatment of scientific conceptions in philosophy deserves praise. Book Second deals with 'Real Knowledge,' knowledge of 'ends'; concludes with a summary of negative inferences, and a final proof that all knowledge is, ultimately, belief. The work is to be commended as an original expression of its writer's own views and difficulties. Its reception in certain circles of dogmatic philosophy ought to be watched with interest. No scientific man will be disposed to find much fault with its sober methods.

MALARIA IN ITALY.

A TRANSLATION by Dr. Eyre of Professor Celli's interesting book upon 'Malaria' * has recently appeared and is most timely. The treatise admirably illustrates the revolution that has been recently wrought in the theories of the epidemiology and prophylaxis of the disease. Professor Celli not only describes the parasites causing the various kinds of malaria afflicting vertebrate animals, but also considers with great fulness the general causes of predisposition to malaria and the various methods that have been suggested for preventing the access of malaria germs to the human organism. The fact that the mosquito has been proved guilty of inoculating human beings with this terrible disease has revealed many opportunities for public sanitation. Not the least interesting part of Professor Celli's book is the portion dealing with the economic and social aspects of malaria in Italy. The great influence of the disease upon the welfare of the Italian people has never been more strikingly portrayed. The mean mortality from malaria in Italy is about 15,000 per year, and it is said that from 1877 to the end of 1897 more than 300,000 cases of malaria occurred in the army alone. A specially interesting section deals with the relation of rice fields to the particular kind of mosquito responsible for malarial infection. It is shown that the rice fields, with their clear and slowly running waters and their typical swamp vegetation, afford peculiarly favorable localities for the breeding of Anopheles, the malaria-bearing mosquito, and that the cultivation of rice has done much to render malaria endemic in certain regions. The author discusses very frankly certain social conditions that expose unduly a large class of the population to malaria. The pictures of the huts in which the peasants of the Campagna live (pp. 174-6) are a striking witness to the truth of his strictures. Taking the book as a whole, it can be fairly claimed that the latest researches upon

* Longmans, Green & Co.

malaria and the conclusions to which they lead are presented in a clear and popular fashion, and will be found both interesting and intelligible by the general reader, albeit the translation stumbles not a little.

BOTANY.

THE *Botanische Centralblatt* has hitherto been published in two series, in which were included original articles and reviews without classification. Chiefly as a result of the representations of a committee of the Society for Plant Physiology and Morphology, this journal announces that, beginning with 1901, the main series will contain only reviews and notices of new literature, while all original articles will be relegated to the 'Beihefte,' each to be subscribed for separately. In order to secure more adequate notice of American papers, two associate editors from America will be added to the staff, and similar arrangements will probably be made in England and other countries. The committee entrusted with the details of arrangement and selection of the American editors consists of Drs. W. G. Farlow, W. F. Ganong, D. T. MacDougal, William Trelease and D. H. Campbell. This action on the part of the *Centralblatt* implies a most notable advance toward securing a better bibliography of botanical literature.

THE completion of 'Die Naturlichen Pflanzenfamilien,' under the editorship of Dr. A. Engler, of the Berlin Botanic Garden, is followed by the announcement that he will undertake the management of a second great systematic work, 'Das Pflanzenreich,' which will consist of a series of monographs of the flora of the world. All the important literature dealing with the taxonomy, distribution, organography, anatomy, morphology of the flower and history of development will be cited at the head of the monograph of each family. General matter will be written in German, but all technical descriptions will be in Latin. Synonyms will be cited in chronological order. More than thirty of the collaborators have already taken up the work of preparation and agreed upon rules of nomenclature. The more recently established families will be fully illustrated. This great work will be produced under the auspices of the Prussian Academy of Sciences by the aid of the Department of Education of Prussia. Monographs upon the banana family (*Musaceae*), by Dr. Karl Schumann; the screw pines (*Pandanaceae*), by Dr. O. Warburg, and the cat-tail family (*Typhaceae*) and burreeds (*Sparganiaceae*), by Dr. P. Graebner, have already appeared. It is to be said that an examination of these papers does not carry out the promise of the prospectus in the matter of rigidity of rules of citation.

THE noble discontent of the science teacher in the schools with the textbooks in botany is calling out a constant stream of elementary texts, the latest of which is by Prof. L. H. Bailey (The Macmillan Company). The subject is taken up in three main sections, dealing with the general anatomy, growth and reproduction, relations to environment and minute structure. Much useful horticultural practise is brought before the young student, but the text is decidedly sketchy in many places, and the book can hardly be said to place proper stress upon exact morphology, although with all Professor Bailey's books it will prove interesting reading to the beginner in botany. In the matter of introducing incidental and immaterial illustrations, much might be said in the way of adverse criticism.

TRAVEL AND EXPLORATION.

THE Ascent of Mt. St. Elias by H. R. H. Luigi, Duke of the Abruzzi, a work published by the Stokes Company, of New York, records the accomplishment of a feat in mountain climbing which is well worth the handsome and profusely illustrated volume brought out in March last year. As a book, it is almost a masterpiece of the bookmaker's art. The appendices are the most valuable portion of the book, and future travelers in such regions will do

well to consult the valuable hints of the chapter upon equipment. Mr. W. D. Wilcox, already a favorite authority upon 'Our Switzerland,' has really given us a continuation of his former work in 'The Rockies of Canada,' published by the Putnams of New York. He treats this wonderful mountain region from the standpoint of the enthusiast, having spent many seasons in the acquisition of his experience. It is easy to see that he is more of a 'mountain lover' than a sportsman, in spite of his creditable accounts of the hunting and fishing to be found in this part of terra incognita. Some space is also given to the character of the Indians. It is almost a pity that he has adopted the 'diary' style, as it detracts somewhat from the literary character of the work.

THE past year has been productive of many volumes bearing upon the East and its problems. The most helpful of these works, two volumes which should be read together, are 'China's Open Door,' by Hon. R. Wildman, and 'The Crisis in China,' by a group of authors, most of them well known. The first volume is the most readable account of the dreary history of China that we have had up to the present time. The bright introduction by the Hon. Charles Denby is a very fitting opening chapter to the volume. It is published by Lothrop, of Boston. The other volume was issued by the Harpers, and discusses the vexed problems of China from various points of view; some of them, curiously enough, having been answered by the disposing power of events, others showing a helpful insight, which it is a pity the 'powers' did not follow. Another volume on America in the East, by W. E. Griffis, published by Barnes & Co., of New York, consists of a delightful series of 'Fourth of July' orations gathered into book form, mainly from the 'Outlook.' From the author's standpoint, Americans have apparently left little for any one else to do in China, Japan and Korea. The last chapters are the best because the most serious. We should remember that while the world moves largely through the influence of enthusiasts, we shall not conquer in the East as much by arms, as by brains and virtue. Still another work published or rather republished by Barnes & Co. is written by an able naval officer, Engineer John D. Ford. Its pleasant accounts of his visits to various portions of the Asiatic coast are well worth the new edition which is brought down to date by a sketch of the Battle of Manila.

A VALUABLE book on the Colombian and Venezuelan republics, prepared by our minister and envoy to these countries, Hon. W. L. Scruggs, is timely, because of its practical hints, its comprehensive study of physical conditions and its descriptions of the magnificent mountain scenery and the luxuriant tropical life. The book will be more attractive to the real student than to the popular reader. Another volume of a different character, rather more of a journalistic effort, on the broader subject of South America, is published by F. G. Carpenter. It is a collection of letters, first published in newspapers and then gathered in more permanent form. The book is a pleasant companion, even if the sketches are somewhat superficial, as is apt to be the case with the traveler away from his authorities. The frontispiece is in rather bad taste, as it is a composition picture of the 'Pretty Girls of Chile.' The volume is printed by the Saalfield Co., of Akron, Ohio.

THE PROGRESS OF SCIENCE.

It is now possible to make a fairly definite statement regarding the enforced resignation of Professor Ross from Leland Stanford Junior University and the subsequent events. Professors are reappointed annually at Stanford, and Professor Ross received his appointment last year somewhat late and after a warning. He attributed this to Mrs. Stanford's disapproval of his economic teachings, and presented his resignation, to take effect at the end of the present academic year. The resignation was accepted on November 14 and Professor Ross published in the daily papers a statement attributing the trouble to Mrs. Stanford's dissatisfaction with his economic views, especially on coolie emigration and municipal ownership. Owing to this publication, Professor Ross's connection with the university was terminated. President Jordan has stated that he was not dismissed on account of his views on Oriental immigration, or on any economic question, but because, in the judgment of the university authorities, he was not the proper man for the place he held. Unfortunately, the affair did not terminate with the retirement of Professor Ross. On the morning after its announcement, Professor Howard, of the Department of History, lectured to his students on the subject, blaming more or less directly the university authorities for their attitude. After an interval of two months, Professor Howard was asked to apologize or resign. He resigned; and as a protest Professor Hudson, of the Department of English, and Professor Little, of the Department of Mathematics, also resigned. These being, in brief, the facts of the case, there has been much private and public discussion as to whether academic freedom has been infringed by the authorities of Stanford University. Thus a committee of the San Francisco alumni has prepared a report upholding the action of the university, while, with substantially the same evidence before it, a committee of three economists has published a pamphlet, supporting Professor Ross in his claim that he has been unjustly treated. It is not true, as has been alleged, that President Jordan acted against his will, under the authority of Mrs. Stanford. The question reduces itself to the more general one as to whether university authorities must retain a professor when his methods are regarded as harmful to the institution.

Professor Ross evidently has the qualities of the reformer rather than of the judicial expert. His stump speeches and illustrated pamphlet supporting free silver in the campaign of 1896 injured the university, and his published writings and his lectures before his classes are extreme in their rhetorical opposition to the wealth and conditions that made Stanford University possible. Thus, if we glance through his articles, we find them strewn with statements such as 'the lawlessness, the insolence and the rapacity of private interests'; "Under the ascendency of the rich and leisured, property becomes more sacred than person, moral standards vary with pecuniary status, and it is felt that 'God will think twice before he damns a person of quality.'" The question is not as to the truth or falsehood of Professor Ross's views, nor as to the desirability of having reformers and even fanatics in the land; it is whether the university, to its own injury, should lend them its authority, whether the professor should have not only the right to investigate and communicate his re-

sults to his peers, but should also be free to involve a university in partisan conflicts. At Stanford the question is complicated by the fact that Mrs. Stanford has so recently given to the university the vast fortune—twenty-seven million dollars—collected by the late Senator Stanford. Professor Ross's teachings being repeated to her, perhaps in a distorted form, she is reported to have said: 'He calls my husband a thief.' Now, it is evident that a university cannot be a proprietary institution, controlled by a rich man or a group of rich men, who dictate the teachings of the professors. But it is equally true that the university professor must work in harmony with certain well-defined traditions. When people unite to accomplish any end, each must sacrifice something of his own freedom. When Mr. Gladstone appeared to be suddenly converted to the advocacy of Irish home rule, his opponents read his thousands of speeches to convict him of inconsistency. Nothing was found in favor of home rule, but neither was there found anything against it. For thirty years, apparently, Mr. Gladstone had been considering the subject, but had been careful not to give rise to dissensions in the Liberal party until he was prepared to make home rule the issue. This is simply an illustration of the fact that the more responsible the position of a man, the more careful must he be in giving expression to views which the man without authority may proclaim on the street corners. When Professor Ross says that teachers are unproductive laborers retained by the idle enjoyers of a parasitic organization to intimidate, beguile and cajole the exploited majority, it seems evident that this is no longer academic freedom of speech, but simply a statement of unfitness for an academic position.

WHILE the troubles at Stanford University are being widely discussed in the United States, English men of science are disturbed by the dismissal of a number of professors from the Royal Engineering College at Coopers Hill. This institution trains engineers for the Civil Service in India, and is under the control of the India Office. The president is an army officer who does not take part in the teaching, and is supposed to act under the direction of a board of visitors. The teaching staff, it appears, has no control of the curriculum or of the general conduct of the college. Under these circumstances, an unsatisfactory state of affairs was reported by a board of enquiry and more than half the teaching staff was somewhat curtly dismissed. Their request for an enquiry having been refused by the Secretary of State for India, a number of leading men of science united in a memorial asking for such an enquiry, and a deputation waited upon Lord George Hamilton to urge it. This deputation, which included Lord Kelvin, Lord Lister, Lord Rayleigh and other leading men of science, called attention to the fact that the college was self-supporting and that there was no need, on the score of economy, for such sweeping dismissals, whereas the abolition of professorships of physics and chemistry would greatly weaken the scientific standing of the college and the training it could give to students of engineering. Lord George Hamilton's reply does not appear to have satisfied the deputation or the English scientific press, and the matter has been called up in Parliament.

THE second annual meeting of the Association of Universities was held at Chicago on February 26, 27 and 28. This association is composed of fourteen leading American universities and holds an annual meeting for the discussion of problems of common interest, it being expected that the president of each university, or his representative, will be in attendance. All the universities were represented at the Chicago meeting. Reporters and the general public are excluded from the sessions, and there is consequently opportunity

for free discussion. At the recent meeting three topics were chiefly discussed. Prof. Ira Remsen, of the Johns Hopkins University, introduced the subject of migration among graduate students, the general opinion being that it was an advantage for the student to attend more than a single university. Prof. W. F. Magie, of Princeton University, introduced a discussion on the type of examination for the doctor's degree, while Prof. W. R. Newbold, of the University of Pennsylvania, introduced the related subject of the extent to which the candidate should be required to show knowledge of subjects not immediately connected with his major subject. The consensus of opinion here seemed to be that the student should not be examined on courses he has taken, but on the subject of his work or research at the end of his university residence. The third subject for discussion, introduced by Prof. H. P. Judson, of the University of Chicago, was on fellowships; and here it seemed to be the general opinion that the provision for university fellowships is so large that there is danger that men will proceed to investigation who are not competent to do the best work. The plan, suggested by a committee of the American Association for the Advancement of Science, that a week be set aside for the meetings of scientific and learned societies was unanimously approved. Columbia University has, in accordance with the suggestion of this committee, altered its schedule for next year, so that the first full week after Christmas may be used for a Convocation Week, and it is to be hoped that other institutions will unite in this movement, and that our various societies will next year meet during the week with which the new year begins. As Christmas occurs this year on Wednesday, there is scarcely time for the meetings during that week, and it will consequently be necessary to hold them the following week.

THE bill establishing a National Bureau of Standards, which was passed by Congress in the closing hours of the session, is a measure of unusual importance for science and for industry. As we have already pointed out, such an institution has long been urgently needed. Germany expends $116,000 annually on its corresponding institutions, and it is not difficult to trace an immediate connection between its Reichsanstalt and the supremacy of German scientific instruments and the increasing manufactures and export trade of the nation. Great Britain has recently been persuaded by the British Association and the Royal Society to extend its work, and is now erecting a new physical laboratory, while it provides $62,000 annually for the cost of its different institutions engaged in standardizing and experimental tests. In the United States the sum of only $10,400 has hitherto been set aside for the Bureau of Standard Weights and Measures, which has now been converted into a National Bureau of Standards. For the bureau a building is to be erected which may cost $250,000, though only $100,000 is at present appropriated; $25,000 is allowed for land and $10,000 for equipment. The salaries amount to over $27,000 annually and the sum of $5,000 is given for current expenses. The bureau has been inaugurated under the most favorable auspices. Urged by scientific men and societies, on the one hand, and by engineers and manufacturers, on the other, the bill passed both Houses of Congress almost without opposition. This was in large measure due to Secretary Gage and to the Hon. James H. Southard, chairman of the Committee on Coinage, Weights and Measures, who gave the measure careful consideration and, impressed with its importance, used every effort to secure its passage. President McKinley has already appointed a most excellent director in Professor Stratton, who has now leave of absence from the University of Chicago to take charge of the Bureau of Weights and Measures, and it is certain that the

other officers will be selected with equal wisdom.

THE establishment of a National Bureau of Standards was the most important scientific measure passed by Congress, but scientific work in many directions was enlarged by increased appropriations, especially in the U. S. Geological Survey and in the U. S. Department of Agriculture. In the latter a reorganization was effected, a number of divisions being united to form four bureaus—Plant Industry, Forestry, Chemistry and Soils. The chiefs of these bureaus receive salaries of $3,000, an increase of $500, and the salaries of some of the scientific experts are increased. Congress did not, however, find time to attend to the affairs of the U. S. Naval Observatory. An amendment was introduced in the naval appropriation bill by Senator Chandler which creates a board of visitors and requires the superintendent to be a line officer of the navy. So far from being a reform, this is distinctly a backward step. The board of visitors which has been created has no power, and with this board, the naval officer, who is superintendent, and the astronomical director, the Observatory has no real head. This amendment was rejected by the House of Representatives, but, after strenuous resistance by the House conferees, was finally passed, with a proviso that the present state of affairs should continue only 'until further legislation by Congress.' It is to be hoped that this legislation will not be long delayed and that the bill introduced by Senator Morgan will be passed at the next session of Congress. In the meanwhile the unfortunate state of affairs at the Observatory is emphasized by the fact that the superintendent has placed the astronomical director under arrest for trial by court martial, owing, it is alleged, to his having used influence against the superintendent.

A NEW STAR has appeared in the constellation Perseus. It is the most striking object of its class which has been seen for three centuries. Its position is, R. A. 3h. 24m. 24s., Dec. North, 43° 33' 42", which is near that of the famous bright variable star, Persei (Algol). This *Nova* was discovered and announced by Anderson, of Edinburgh, and when found by him on the night of February 21 was of about the third magnitude. By the following night it had risen to the first magnitude and was one of the brightest stars in the evening sky. Such an object, in an especially well-observed region of the sky, could not easily escape notice, and it was independently discovered by probably a dozen observers in different countries. At the Harvard Observatory a careful record is kept of the sky from week to week by means of photographs, which are taken at frequent intervals. Some of these photographs are made with lenses of such short focal length and wide field that the whole sky would be covered by about fifty plates. The announcement of the *Nova* was received there February 22. The latest photographs of the region of Perseus had been made on the night of February 19. One of these showed stars as faint as the eleventh magnitude, but the *Nova* did not appear upon it. On February 19, therefore, it was fainter, at least, than the eleventh magnitude. On February 21 its magnitude was 2.7, but by February 25 it had fallen to 1.1. At the present time (March 9) it is of about the fourth magnitude and may be expected to disappear from view by the naked eye within a few days. The astronomical world is to-day so well equipped for research in the line of spectrum analysis and the present object is so suitable for such investigation that we may expect a more satisfactory study of this new star than has ever before been obtained of any similar object. There will doubtless be abundant materials for learning the smallest changes during a portion of the life history of this star; but, for the period of the increase of light, from the instant it became visible till it reached its maximum, the observations may prove to be few. On this account it is fortunate that at the Har-

vard Observatory photographs of the spectrum were obtained on February 22 and February 23. On these dates the spectrum was not the typical one which we have learned to expect for Novæ, but instead was of the Orion type, consisting of a strong, continuous spectrum crossed by dark lines. Between February 23 and February 24, however, a wonderful transformation took place. Since the latter date the spectrum has consisted in large part of the bright and dark bands which are characteristic of the spectra of Novæ.

THE first new star of which there is authentic record appeared 134 B. C. During the two thousand years which have since elapsed, nineteen more have been noted, making about one per century. This can by no means represent the true number of such stars which have appeared during that time. Doubtless only a few of the brightest have been seen. Of the twenty on record, thirteen belong to the century just ended, and six to the last decade, five of which were found on Harvard photographs. Of all the stars visible in the largest telescopes, not more than one in ten thousand can be seen by the naked eye. Thirteen of the Novæ were bright enough to be seen by the unaided vision. At the same rate for the fainter stars, if we may assume that the number of Novæ corresponds in some degree to the whole number of stars for the different magnitudes, several thousand new stars must have escaped observation during each century. No entirely satisfactory explanation has yet been given of these remarkable objects. From dark, or at least from extremely faint bodies, they suddenly blaze up and slowly fade away. Any theory which aims to explain the phenomena must at least account for certain leading facts. The increase of light is very sudden and very great. The decrease is slower and sometimes irregular, but no collision can have occurred such as would change a solid body into a gaseous, otherwise ages, not weeks, would be required for the cooling. The spectrum is generally composite, composed of bright and dark lines or bands. The bright bands are displaced toward the red, the dark bands toward the violet. If this separation is due to the relative motions of two gaseous masses, the velocities concerned appear to exceed those found elsewhere in the universe. The *Nova* sometimes remains as a permanent telescopic object with the spectrum of a planetary nebula. The problem might be somewhat simplified if the broadening of the lines could be due to the Zeeman effect from the presence of a strong magnetic field. It appears probable that the phenomena are due either to some outburst in the dark world itself, or else to the collisions of a solid dark world passing through a dense meteor swarm. It is to be hoped that a discussion of all the materials, which will be obtained at the different observatories during the next few weeks, may serve to formulate a theory of new stars which will receive the general approval of the scientific world.

THE investigations on agricultural soils which are being conducted in this country are probably unsurpassed in quality and extent by those of any country, unless it be Russia, where a very systematic and extensive line of investigations, including a survey and classification of the soils of the whole country has been in progress for a number of years. The work in this country has been carried on mainly by a number of the agricultural experiment stations and the Division of Soils of the National Department of Agriculture. The report of the Field Operations of the Division of Soils for 1899, by Prof. Milton Whitney and a number of his assistants, lately issued, is a report of progress in surveying the soils of the United States. During the year areas aggregating about 720,000 acres were studied in the field and mapped. This work has been largely confined to localities in New Mexico, Utah and Colorado, and a special feature made of studies on the ac-

cumulation of alkali in the soil and its causes, means of ameliorating these conditions, and similar problems relating to alkali soils. A variety of local conditions were met with, which call for specific treatment. In a number of regions reconnoitered, the present accumulation of alkali, which has frequently nearly reached the limit of tolerance of plants, is attributed to lack of good natural drainage. The evaporation in these arid or semi-arid regions is unusually great, and with insufficient rainfall and injudicious irrigation tends to an accumulation of the alkali salts near the surface. With good natural drainage and proper application of irrigation water these salts would be in a measure washed out of the soil and the soil moisture maintained at nearly the same concentration as the water supply. But, in some cases, the irrigation water itself has become so charged with alkali as to call for the exercise of judgment in its use. "It may be perfectly safe to use water of a relatively high salt content on certain well-drained soils, when it would be ruinous to allow the same water to be used on a properly-drained soil containing a high salt content." The maps which accompany the report make it possible to determine the limit of the salt content of the water which it would be safe to use in the localities reconnoitered. The seepage waters are mentioned as another frequent cause of increase of the alkali in the soil. For instance, in the Salt Lake Valley, the oldest of the modern irrigated districts, the lower levels, which were formerly the most productive soils of the valley, have been damaged and in some cases ruined by seepage waters and alkali. In general, where the conditions are favorable and the expense would be warranted, underdrainage with tile is recommended as a remedy for excessive alkali in the soil. This remedy is considered entirely practical for reclaiming extensive areas, which at present have become nearly or quite worthless.

WE record with regret the following deaths, which have occurred during the month: Dr. George M. Dawson, the eminent director of the Geological Survey of Canada, died on March 2 at the early age of fifty-one years, after an illness of only two days. He was well-known for his important contributions to the geology of Canada and for his conduct of the geological survey and of various commissions. Prof. G. F. Fitzgerald, who has held since 1881 the chair of experimental philosophy in the University of Dublin, and is well known for his researches on magnetism and in other directions, died on February 21 at the age of forty-nine years. Dr. Walter Myers died from yellow fever in Brazil, whither he had gone from the Liverpool School of Tropical Medicine to investigate the disease. He was only twenty-nine years of age. Dr. Jacob Georg Agardh, the eminent Swedish phycologist, died at Lund, on January 17, aged eighty-eight years. The death is also announced, in his seventieth year, of Dr. Bernhardt Danckelmann, for the last thirty-five years director of the Prussian Royal Academy of Forestry at Eberswalde. He was one of the first to advocate the training of foresters in special colleges, and was the author of important works on forestry.—The degree of LL.D. has been conferred by St. Andrew's University on Mr. Alexander Agassiz, of Harvard University, and by the University of Pennsylvania on President Henry S. Pritchett, of the Massachusetts Institute of Technology.—The Cullum Medal of the American Geographical Society has been conferred on President T. C. Mendenhall, of the Worcester Polytechnic Institute.—The Amsterdam Society for the Advancement of Natural Science and Medicine has awarded its gold Swammerdam medal for 1900 to Professor Gegenbaur, of Heidelberg.—Mr. J. E. Spurr, of the U. S. Geological Survey, has accepted an invitation of the Turkish Government to make an investigation of the mineral resources of the country.

INDEX.

THE NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS.

Abruzzi, Duke of, Ascent of Mt. St. Elias, 661.
Aerial Navigation, Recent Progress in, CHARLES H. COCHRANE, 616.
Agricultural, Experiment Stations, 102; Soils, 667.
Agriculture, 101, 328; Department of, 332; Appropriations for the, 556.
Aitken's Road Making and Maintenance, 438.
Alcohol, Utilization of, in the Human Body, 554.
American, Astronomical Instruments, 331; Hall of Fame, 108.
Anthropological Department of the British Association, Address before the, T. H. HUXLEY, 267.
Appropriations for the Department of Agriculture, 556.
Aquarium, The New York, CHARLES L. BRISTOL, 405.
Artificial Propagation of Fish, 335.
Asphaltum for a Modern Street, S. F. PECKHAM, 225.
ATKINSON, EDWARD, Distribution of Taxes, 54.
Atkinson's Edible and Poisonous Mushrooms, 440.
Atomic Weights, Standard for, 110.
Atwater's Experiments on the Nutritive Value of Alcohol, 554.
Autonous, Story of, WILLIAM HENRY HUDSON, 276.
AVEBURY, LORD, Huxley's Life and Work, 337.

Bacteria, and Fermentation, 445; and Dairy Products, 559.
Bacterial Life, Effect of Physical Agents on, ALLAN MACFADYEN, 238.
Bailey's, Cyclopedia of American Horticulture, 327; Botany, 661.
BAILEY, SOLON I., The Planet Eros, 641.
Battleship Building, Rapid, WALDON FAWCETT, 28.
Bibliographies of Engineering, 439.
Botany, 327, 661.
BRADLEY, W. P., Submarine Navigation, 156.
BRISTOL, CHARLES L., The New York Aquarium, 405.
British Association for the Advancement of Science, Address of the President, SIR WILLIAM TURNER, 34.
Burckhalter on the Photography of Solar Eclipses, 214.

CAMPBELL, W. W., James Edward Keeler, 85.
Carpenter on South America, 662.
Carus's History of the Devil, 440.
Celli on Malaria, 660.
Century of the Study of Meteorites, OLIVER C. FARRINGTON, 429.
Chapters on the Stars, SIMON NEWCOMB, 3, 130, 307, 413, 449.
Cheese-making, Microbes in, H. W. CONN, 148.
Chicago, University of, What it Stands for, EUGENE PARSONS, 652.
China, WILLIAM BARCLAY PARSONS, 69; Scientific Knowledge regarding, 107; Crisis in, 662.
China's Open Door, Wildman's, 662.
Chinese Commerce, WILLIAM BARCLAY PARSONS, 193.
Christian Science, J. EDWARD SMITH, 434; JOSEPH JASTROW, 550.
Christmas Island, 98.
Cities, Growth of, 221.
COCHRANE, CHARLES H., Recent Progress in Aerial Navigation, 616.
Comparative Physiology, Loeb's, 328.
CONN, H. W., Microbes in Cheese-making, 148.
CRAWLEY, EDWIN S., Geometry: Ancient and Modern, 257.
Cuban Teachers, Height and Weight of, DUDLEY ALLEN SARGENT, 480.
Cyclopedia of American Horticulture, Bailey's, 327.

Dairy Products, Bacteria and, 559.
Davidson's History of Education, 218.
Dephlogisticated Air, JOSEPH PRIESTLEY, 115.
Development of Unfertilized Eggs, 443.
Devil, History of the, Carus's, 440.
DEXTER, EDWIN G., Suicide and the Weather, 604.
Distances, Science of, GEORGE S. ROBERTSON, 526.
Distribution of Taxes, EDWARD ATKINSON, 54.

Eastman's Manual of Paleontology, 98.
Eclipses, Photography of Solar, 214.

Economic Life of France, EDWARD D. JONES, 287.
Education, 218, 329; Two Contemporary Problems in, PAUL H. HANUS, 585.
Eggs, Development of Unfertilized, 443.
Electrical Charges of Atoms, 106.
Elements, Inert, 446, 558.
ELLIS, HAVELOCK, Study of British Genius, 372, 540, 595.
EMORY, FREDERIC, The Foreign Trade of the United States, 625.
Energy and Work of the Human Body, EDWARD B. ROSA, 208.
Engineering, 438.
Engler's Die Naturlichen Pflanzenfamilien, 661.
Eros, The Planet, SOLON I. BAILEY, 641.
Evermann and Jordan on the Fishes of North and Middle America, 100.
Existence of Air in the Acid of Nitre. ANTOINE-LAURENT LAVOISIER, 123.
Explosive, High, Throwing from Powder Guns, HUDSON MAXIM, 493.

FAIRBANKS, HAROLD W., Pyramid Lake, Nevada, 505.
Famines and Sun Spots, 335.
FARRINGTON, OLIVER C., A Century of the Study of Meteorites, 429.
FAWCETT, WALDON, Rapid Battleship Building, 28.
Ferments, Inorganic, 220.
Fish, Artificial Propagation of, 335; Commission, 334.
Fishes of North and Middle America, Jordan and Evermann, 100.
Fleury's, Medicine and the Mind, 216.
Flies and Typhoid Fever, L. O. HOWARD, 249.
Flournoy's Des Indes à la Planète Mars, 217.
Flow of Rocks, 445.
Folk-lore, 440.
Foreign, Plants, Introduction of, 332; Trade of the United States, FREDERIC EMORY, 625.
Forest Reservations, 222.
Forestry, 327; Yale School of, 221; and Irrigation, 332.
Foundations of Knowledge, Ormond's, 552.
France, Economic Life of, EDWARD D. JONES, 287.
Freedom and 'Free-will,' GEORGE STUART FULLERTON, 183.
Frizell's Water Power, 440.
FULLERTON, GEORGE STUART, Freedom and 'Free-will,' 183.

GARRISON, GEORGE P., Scientific and Literary Historians, 92.
Genius, A Study of British, HAVELOCK ELLIS, 372, 540, 595; Men of, Origin of, C. W. SUPER, 657.
Geologist Awheel, WILLIAM H. HOBBS, 515.
Geometry: Ancient and Modern, EDWIN S. CRAWLEY, 257.
Government, Science and the, 556.
Green's Vegetable Physiology, 327.
Growth of Cities, 221.

Habits, Formation of, in the Turtle, ROBERT MEARNS YERKES, 519.
HANUS, PAUL H., Two Contemporary Problems in Education, 585.
Hastie on Kant's Cosmogony, 659.
Height and Weight of the Cuban Teachers, DUDLEY ALLEN SARGENT, 480.
Historians, Scientific and Literary, GEORGE P. GARRISON, 92.
History, Rescue Work in, DAVID STARR JORDAN, 81.
HOBBS, WILLIAM H., The Geologist Awheel, 515.
HOWARD, L. O., Flies and Typhoid Fever, 249.
HUXLEY, T. H., Address before the Anthropological Department of the British Association, 267.
Huxley's Life and Work, LORD AVEBURY, 337.
Hypnotism in Mental and Moral Culture, Quackenbos's, 214.

Index to Literature of Animal Industry, Thompson's, 328.
Inert Elements, 446, 558.
Ingersoll's Nature's Calendar, 99.
Inoculation of Soils, 220.
Inorganic Ferments, 220.
Inventor of the Sewing Machine, VINDICATOR, 551.
Irrigation, Use of Water in, 101; and Drainage, King on, 439; Forestry and, 332.

JASTROW, JOSEPH, Christian Science, 550.
Jastrow's Fact and Fable in Psychology, 328.
Johnston and Mead on the Use of Water in Irrigation, 101.
JONES, EDWARD D., Economic Life of France, 287.
JORDAN, DAVID STARR, Rescue Work in History, 81.
Jordan and Evermann's Fishes of North and Middle America, 100.

Kant and the Nebular Hypothesis, 659.
Keeler, James Edward, W. W. CAMPBELL, 85; Portrait of, 2.
King on Irrigation and Drainage, 439.
Knowledge and Belief, 659.

LAVOISIER, ANTOINE-LAURENT, Existence of Air in the Acid of Nitre, 123; Nature of Acids, 127.
Lavoisier, 219; Monument (frontispiece), 114.

Leeuwenhoek, Malpighi, Swammerdam, WILLIAM A. LOCY, 561.
Lippincott's, Storage of Water on Gila River, Arizona, 439.
Loeb's Comparative Physiology of the Brain and Comparative Psychology, 328.

MacCunn's 'Making of Character,' 329.
MACFADYEN, ALLEN, Effect of Physical Agents on Bacterial Life, 238.
Malaria, GEORGE M. STERNBERG, 360; In Italy, Celli's, 660.
Malpighi, Swammerdam and Leeuwenhoek, WILLIAM A. LOCY, 561.
MAXIM, HUDSON, Throwing a High Explosive from Powder Guns, 493.
Mead and Johnston's Use of Water in Irrigation, 101.
Medicine and the Mind, Fleury's, 216.
Meteorites, A Century of the Study of, OLIVER C. FARRINGTON, 429.
Microbes in Cheese-making, H. W. CONN, 148.
Milk of Tuberculous Cows, 559.
Mosquitoes, and Malaria, 109; Yellow Fever and, 219.
Municipal, Government Now and a Hundred Years Ago, CLINTON ROGERS WOODRUFF, 60; Water-works Laboratories, GEORGE C. WHIPPLE, 172.
Museum, National, 557.
Mushrooms, Edible and Poisonous, Atkinson's, 440.
Mycology, 440.

National, Museum, 557; Physical Laboratory of Great Britain, 558; Bureau of Standards, 330, 665.
Nature's Calendar, Ingersoll's, 99.
Naval Observatory of the United States, 442, 557, 666.
Navigation, Submarine, W. P. BRADLEY, 156.
Nebular Hypothesis, 106; Kant and the, 659.
NEWCOMB, SIMON, Chapters on the Stars, 3, 130, 307, 413, 449.
Newspaper Science, 447.
New York Aquarium, CHARLES L. BRISTOL, 405.
Nobel Prizes, 107.

Observatory, Naval, 442, 557, 666.
Obscurity in Scientific Publications, AN EDITOR, 324.
Ormond's Foundations of Knowledge, 552.
Ornithology, 100.

PACKARD, ALPHEUS S., Prehistoric Tombs of Eastern Algeria, 397.
Paleontology, 98.
PARSONS, W. BARCLAY, China, 69; Chinese Commerce, 193.
PARSONS, WILLIAM BARCLAY, China, 69; Chinese Commerce, 193.
Pearson's Grammar of Science, C. S. PEIRCE, 296.
PECKHAM, S. F., Asphaltum for a Modern Street, 225.
PEIRCE, C. S., Pearson's Grammar of Science, 296.
Perseus, A New Star in, 666.
Philippines Two Hundred Years Ago, E. E. SLOSSON, 393.
Philosophy, 103.
Physical Agents, Effect on Bacterial Life, ALLAN MACFADYEN, 238.
Photography of Solar Eclipses, 214.
Population of the United States during the Next Ten Centuries, H. S. PRITCHETT, 49; CHAS. E. WOODRUFF, 656.
Prehistoric Tombs of Eastern Algeria, ALPHEUS S. PACKARD, 397.
PRIESTLEY, JOSEPH, on Dephlogisticated Air, 115.
PRITCHETT, H. S., Population of the United States during the Next Ten Centuries, 49.
Prodigies, 223.
Psychical Institute, The Proposed, 109.
Psychological Congress, The International, 108.
Psychology, 214; Fact and Fable in, Jastrow's, 328.
Pyramid Lake, Nevada, HAROLD W. FAIRBANKS, 505.

Quackenbos's Hypnotism in Mental and Moral Culture, 214.

Random Remarks of a Lady Scientist, REBECCA SHARPE, 548.
Rapid Battleship Building, WALDON FAWCETT, 28.
Rate of Express Trains, 111.
Rescue Work in History, DAVID STARR JORDAN, 81.
Retardation of Science, AN EDITOR, 95.
Road Making and Maintenance, Aitken's, 438.
ROBERTSON, GEORGE S., Science of Distances, 526.
Rocks, Flow of, 445.
ROSA, EDWARD B., Energy and Work of the Human Body, 208.
Royal Engineering College, 664.

SARGENT, DUDLEY ALLEN, Height and Weight of the Cuban Teachers, 480;
Schiaparelli, 111.
Science, and the Government, 556, 666; in the Nineteenth Century and in the Reign of Queen Victoria, 555; of Distances, GEORGE S. ROBERTSON, 526; Retardation of, AN EDITOR, 95.
Scientific, and Literary Historians, GEORGE P. GARRISON, 92; Items, 112, 224, 336, 447, 560, 668; Societies, 443.
Scruggs on the Colombian and Venezuelan Republics, 662.

Sewing Machine, Inventor of, VINDICATOR, 551.
SHARPE, REBECCA, Random Remarks of a Lady Scientist, 548.
Shooting Stars, 553.
SLOSSON, E. E., The Philippines Two Hundred Years Ago, 393.
SMITH, J. EDWARD, Defense of Christian Science, 434.
Societies, Scientific, 443.
Soils, Inoculation of, 220.
St. Elias, Ascent of Mt., 661.
Standard for Atomic Weights, 110.
Standardizing Bureau, 330, 665.
Stanford University, 663.
Star, New, in Perseus, 667.
Stars, Chapters on the, SIMON NEWCOMB, 3, 130, 307, 413, 449.
Stirling's What is Thought?, 103.
STERNBERG, GEORGE M., Malaria, 360.
Storage of Water on Gila River, Arizona, Lippincott's, 439.
Story of Autonous, WILLIAM HENRY HUDSON, 276.
Suicide and the Weather, EDWIN G. DEXTER, 604.
SUPER, C. W., Origin of Men of Genius, 657.
Swammerdam, Malpighi and Leeuwenhoek, WILLIAM A. LOCY, 561.

THURSTON, R. H., Law of Substance, 467.
Tillson on Street Pavements and Paving Materials, 438.
Tobacco, Sumatra, Growth of, 446.
Tombs of Eastern Algeria, Prehistoric, ALPHEUS S. PACKARD, 397.
Topographic Surveying, Wilson on, 438.
Trade, Foreign, of the United States, FREDERIC EMORY, 625.
Trains, Rate of, 111.
Travel and Exploration, 661.
Tuberculous Cows, Milk of, 559.
TURNER, WILLIAM, Address of the President before the British Association for the Advancement of Science, 34.
Turner's Knowledge and Belief, 659.
Turtle, Formation of Habits in, ROBERT MEARNS YERKES, 519.
Typhoid Fever, Flies and, L. O. HOWARD, 249.

Universities, Association of, 664.
Utilization of Food and Alcohol in the Human Body, 554.

Viereck, on Latin in the German Gymnasium, 218.
VINDICATOR, The Inventor of the Sewing Machine, 551.
von Zittel's Manual of Paleontology, Eastman's, 98.

Water, Use of, in Irrigation, Mead and Johnston's, 101; Power, Frizell on, 440.
WATTS, HARVEY MAITLAND, The Weather vs. the Newspapers, 381.
Weather, vs. the Newspapers, HARVEY MAITLAND WATTS, 381; Suicide and the, EDWIN G. DEXTER, 604.
WHIPPLE, GEORGE C., Municipal Water-works Laboratories, 172.
Wilcox on the Rockies of Canada, 662.
Wildman on the Crisis in China, 662.
Wilson's Topographic Surveying, 438.
WOODRUFF, CHAS. E., The Population of the United States during the Next Ten Centuries, 656.
WOODRUFF, CLINTON ROGERS, Municipal Government Now and a Hundred Years Ago, 60.

Yale Forestry School, 221.
Yellow Fever and Mosquitoes, 219.
YERKES, ROBERT MEARNS, Formation of Habits in the Turtle, 519.

Zittel, von, Manual of Paleontology, 98.
Zoology, 99.

GENERAL LIBRARY,
UNIV. OF MICH.
MAR 29 1901

GENERAL LIBRARY
UNIV. OF MICH.
MAR 29 1901

Vol. LVIII. No. 6. APRIL, 1901.

THE POPULAR SCIENCE MONTHLY.

EDITED BY J. McKEEN CATTELL.

CONTENTS.

Malpighi, Swammerdam and Leeuwenhoek. Professor William A. Locy 561

Two Contemporary Problems in Education. Professor Paul H. Hanus 585

A Study of British Genius. Havelock Ellis 595

Suicide and the Weather. Professor Edwin G. Dexter 604

Recent Progress in Aerial Navigation. Charles H. Cochrane 616

The Foreign Trade of the United States. Frederic Emory 625

The Planet Eros. Professor Solon I. Bailey 641

Discussion and Correspondence:

What Chicago University Stands For: Eugene Parsons. The Population of the United States during the Next Ten Centuries: Chas. H. Woodruff, U. S. A. Origin of Men of Genius: President Chas. W. Super 652

Scientific Literature:

Kant and the Nebular Hypothesis; Knowledge and Belief; Malaria in Italy; Botany; Travel and Exploration 659

The Progress of Science:

Stanford University and Academic Freedom; The Royal Engineering College; The Association of Universities; The National Bureau of Standards; Other Legislation by Congress; The New Star in Perseus; Other New Stars and their Origin; The Investigation of Agricultural Soils; Scientific Items 663

Index to Volume LVIII 669

McCLURE, PHILLIPS & COMPANY,
NEW YORK: 141 EAST 25TH STREET.
LONDON: 10 NORFOLK STREET, STRAND, W. C.

Single Number, 25 Cents. Yearly Subscription, $3.00.

COPYRIGHT, 1901, BY McCLURE, PHILLIPS & COMPANY.
Entered at the Post Office at New York, and admitted for transmission through the mails as second-class matter.

Bound Volume LVIII

OF THE

POPULAR SCIENCE MONTHLY

May to October, inclusive, 1900

NOW READY FOR DELIVERY

Price (including delivery charges) Green Cloth, Gold Lettering . . $2.50

THE BOUND VOLUMES OF THE

Popular Science Monthly

AMONG the names of distinguished contributors to THE POPULAR SCIENCE MONTHLY in the earlier part of its career are the following, selected at random from the first few numbers:

JOHN TYNDALL
HERBERT SPENCER
R. A. PROCTOR
HENRY WARD BEECHER
CHARLES KINGSLEY
ALFRED RUSSELL WALLACE
JOSEPH LE CONTE
T. H. HUXLEY
HENRY MAUDSLEY
ANDREW D. WHITE
JOHN FISKE
CHARLES W. ELIOT
FRANCIS GALTON
ERNEST HAECKEL

Some of the earlier volumes of THE POPULAR SCIENCE MONTHLY are out of print. Old subscribers who have files of these missing volumes, in good condition, can have them bound in the green cloth of the series by sending the copies to us, charges prepaid, to be promptly returned to the sender. The charge in such cases will be $1.00 per volume.

To such persons as prefer to employ the services of their own binder, binding cases (green cloth, gold lettering) will be supplied at 50 cents each.

RATES

Volumes I to LV, inclusive, except volumes I, II, V, XX, XXI, XXIII, XXX, XXXIII, and XXXIV, which are out of print, green cloth, per volume, - - $3.00

Volume LVI and subsequent volumes, green cloth, - - - - - - 2.50

Back Numbers, from May, 1872, to and including the issue of December, 1899, except such as are out of print, a list of which will be given on request, per copy, 50 cents.

Subsequent copies, - - - - - - - - - - - - 25 cents.

McCLURE, PHILLIPS & CO.

141-155 EAST 25th STREET NEW YORK

APPLETONS

THE sudden flaming up of a star from the tenth magnitude to the first—an event of rare occurence—has turned the eyes of millions to the skies of night. Few persons realize how much delight can be obtained with a good opera glass. Garrett P. Serviss has written a book entitled "*Astronomy with an Opera Glass.*" It was remarkably successful. Most timely is his new book:—

Pleasures of the Telescope

A Descriptive Guide for Amateur Astronomers and all Lovers of the Stars. By GARRETT P. SERVISS. Illustrated with charts of the heavens, and with drawings of the planets and charts of the moon. 8vo, cloth, $1.50.

New Edition, Revised and Enlarged
Velázquez's Pronouncing .: :: ::

DICTIONARY OF THE SPANISH AND ENGLISH LANGUAGES.

First Part: Spanish-English. Large 8vo, 710 pages. Half morocco, $3.50.
Part II. English-Spanish, in preparation.
Velázquez has been modernized by competent modern scholars
Part I contains eight thousand new titles and several hundred new idioms. The vocabulary of commercial and scientific terms has been greatly amplified; there is greater accuracy of definition and usage.
The *Outlook* says: "It should take its deserved place as THE Spanish Dictionary."
The *Nation* says: "So far as we have been able to judge by tests here and there, the revisers have done their work with sound scholarship and excellent taste. The NEW VELAZQUEZ is happily timed for the new vogue of Spanish."

A Masterpiece of Biography.

LIFE AND LETTERS OF THOMAS HENRY HUXLEY.

Edited by his son LEONARD HUXLEY.
In Two Volumes, 8vo, 549, 547 pages. Illustrated. Index. Cloth, $5 00 net.
THIRD EDITION.

The universal press has acclaimed Huxley's biography as one of the most important as it is one of the most enthralling books of the nineteenth century.
Mr. E. L. Godkin calls Huxley's "one of the most instructive and brilliant of English lives."
This opinion is echoed by the press everywhere. Here are a few of the typical voices:
"Extremely valuable and interesting letters, all characteristic, connected by a well-written, consecutive narration."—London *News.*
"The work is rich in personal, literary, social and scientific interests, while as a biography it is fascinating and valuable."—N. Y. *Observer.*
It was voted by a majority of the readers of the London Academy the second best book of 1900.

CHINA:

Travels and Investigations in the "Middle Kingdom"—A Study of Its Civilization and Possibilities. Together with an account of the Boxer War, the Relief of the Legations and the Re-establishment of Peace. By JAMES HARRISON WILSON, A.M., LL. D., late Major-General United States Volunteers and Brevet Major-General United States Army.
Third edition, revised throughout, enlarged and reset.

12mo. Cloth, $1.75.

General Wilson has been twice in China, and has had extraordinary opportunities of observation, so that this work, which is practically new, will be invaluable to all who desire to understand the CHINA OF TO-DAY.
The Honorable Walter Q. Gresham, late Secretary of State, pronounced this work, on its first appearance, to be the most practical and interesting ever written on China.
This new edition contains a great amount of fresh and timely information, so that Gresham's praise deserves to be doubly emphasized

HISTORY OF CHINESE LITERATURE.

By HERBERT A. GILES, M.A., LL.D. (Aberd.), Professor of Chinese in the Univ. of Cambridge.

One vol. 12mo, 557 pp.; Index. Cloth, $1.50.
The 10th volume in the Literature of the World Series.

"Few recent histories of literature are more pregnant with new and interesting material than this. There is nothing like it in any library, and one may say, with assurance, that there is not a dull page in it."—Boston *Transcript.*
"The reading of Professor Giles's 'History of Chinese Literature' is at the same time astounding and fascinating. One is astonished at the presentation of such an immense amount of information, as well as at the fluent, charming manner in which it is conveyed. Upon opening the book one naturally expects to find everything as dry as the Desert of Gobi; which expectation is very quickly shattered. The title over the gateway may be forbidding, but once inside the garden one finds it a garden of delight.'—Philadelphia *Evening Telegraph.*

D. Appleton & Company

72 FIFTH AVENUE ◊ NEW YORK

The North American Review

1815 1901

WHAT THE PAPERS HAVE SAID OF IT RECENTLY

NEW YORK TIMES

During its many years of publication THE NORTH AMERICAN REVIEW has devoted its attention to the gravest topics, and has always treated these with marked attention. It has always been impartial, giving both sides of the questions which attract public thought. Its aim has been to elevate public opinion by means of tempered discussion, and its achievements in this special direction have been most remarkable.

NEW YORK MAIL AND EXPRESS

The scope of THE NORTH AMERICAN REVIEW under its new management and the invariable excellence of its articles have been praised by us so often, and are, in fact, so well known now, that further expatiation upon its many merits is superfluous.

ZION'S HERALD (BOSTON, MASS.)

The February number of THE NORTH AMERICAN REVIEW unquestionably attests the fact that the editor has determined to hold this historic monthly to the very highest standard.

THE SCRANTON REPUBLICAN (PA.)

While THE NORTH AMERICAN REVIEW is American in name, and publishes from month to month the weightiest and most authoritative discussions of the foremost American topics, it is the most cosmopolitan periodical in the world, seeking the co-operation of the great writers and statesmen of all nations on subjects regarding which the best citizens of the United States desire to be informed.

We have made arrangements with Messrs. Harper & Brothers to send any one of their periodicals at a special price in combination with THE NORTH AMERICAN REVIEW, as follows:

COMBINATION OFFERS FOR 1901

THE NORTH AMERICAN REVIEW
Subscription price, $5 per year
50 cents per copy.

AND

HARPER'S MAGAZINE ($4 00 a year)	$8 00
HARPER'S WEEKLY ($4 00 a year)	8 00
HARPER'S BAZAR ($4 00 a year)	8 00

THE NORTH AMERICAN REVIEW, Franklin Square, N. Y.

For Nature Lovers

A STANDARD AUTHORITY

HOW TO KNOW THE WILD FLOWERS

By Mrs. William Starr Dana (Mrs. Parsons)

A Guide to the Names, Haunts, and Habits of our Common Wild Flowers. With 48 full-page colored plates by ELSIE LOUISE SHAW, and 110 full-page illustrations by MARION SATTERLEE. 60th thousand. Crown 8vo, $2.00 *net*.

"OF all the aids to the study of nature none has won a wider popularity than Mrs. William Starr Dana's 'How to Know the Wild Flowers.' Here accurate science is put in a simple, practical form, and presented with unusual grace of style, and the book has become the favorite companion for open-air rambles of flower-lovers who were daunted by the dry particularity of the average botany."—Chicago *Evening Post*.

"EVERY flower-lover who has spent weary hours puzzling over a botanical key, in the effort to name unknown plants, will welcome this satisfactory book, which stands ready to lead him to the desired knowledge by a royal road. The book is well fitted to the need of many who have no botanical knowledge and yet are interested in wild flowers."—*The Nation*.

* * *

HOW TO KNOW THE FERNS

A Guide to the Names, Haunts, and Habits of our Native Ferns. By FRANCES THEODORA PARSONS (Mrs. Dana). With 144 full-page illustrations, and 6 full-page illustrations from photographs. Crown 8vo, $1.50 *net*.

"THIS is a notably thorough little volume. The text is not voluminous, and even with its many full-page illustrations the book is small; but brevity, as we are glad to see so many writers on nature learning, is the first of virtues in this field. . . . The author of 'How to Know the Ferns' has mastered her subject, and she treats of it with authority."—New York *Tribune*.

"OF the ferns, as of the flowers, she writes as one who not only knows but loves them. The charm of her fern book is as irresistible and pervading as is the charm of nature itself. This gifted and enthusiastic naturalist knows the ferns literally 'like a book,' and her book makes the first lesson of the novice in the lore of fern-life an easy and delightful task."—New York *Mail and Express*.

*** *A new edition of Mrs. Dana's popular book "According to Season," with much additional matter and 32 plates in color, is in preparation.*

OUR NATIVE TREES

AND HOW TO IDENTIFY THEM

By Harriet L. Keeler

With 178 full-page illustrations from photographs, and with 162 illustrations from drawings. Second edition. Crown 8vo, $2.00 *net*.

C. S. SARGENT, *Professor of Arboriculture in Harvard University, says:*

"OF such popular books the latest and by far the most interesting is by Miss Harriet L. Keeler, . . . Miss Keeler's descriptions are clear, compact, and well arranged, and the technical matter is supplemented by much interesting and reliable information concerning the economical uses, the history, and the origin of the trees which she describes."

CHARLES SCRIBNER'S SONS, PUBLISHERS, NEW YORK.

Elementary Mathematics

A Brief History of Mathematics. By the late *Dr. Karl Fink*, Tübingen, Germany. Translated by *W. W. Beman* and *D. E. Smith*. Pp. 345. Cloth $1.50 net (5s 6d. net). Not a book of anecdotes, nor one of biography; but a clear and brief statement of the *facts* of mathematical history. An invaluable work for teachers of mathematics.

On the Study and Difficulties of Mathematics. By *Augustus De Morgan*. With Portrait and Bibliographies of Modern Works on Algebra, the Philosophy of Mathematics, Pangeometry, etc. Pp. viii, 288. Cloth, $1.25 (4s. 6d.) net.
"When the next book of this series is out, send it along. It is the most valuable series published."—*William Bellis*, Central Michigan Normal.

Lectures on Elementary Mathematics. By *Joseph Louis Lagrange*. With Portrait, Biographical Sketch, Marginal Analyses, etc. Cloth. Pp 172. Price, $1.00 (4s. 6d.) net.
"Historical and methodological remarks abound, and are so woven together with the mathematical material proper, and the whole is so vivified by the clear and almost chatty style of the author as to give the lectures a charm for the reader not often to be found in mathematical works."—*Bulletin American Mathematical Society*.

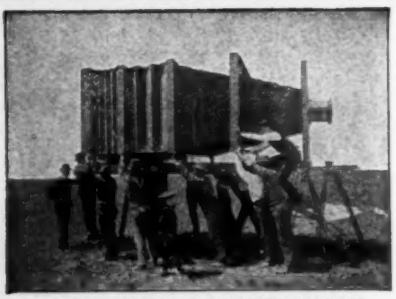
Mathematical Essays and Recreations. By *Herman Schubert*, Professor of Mathematics in Hamburg, Germany. Pp. 149. Cuts, 37. Price, Cloth, 75c. (3s.) net.

Elementary Illustrations of the Differential and Integral Calculus. By *Augustus De Morgan*. New reprint edition. With sub-headings and bibliography of English and foreign works on the Calculus. Cloth Price, $1.00 (4s. 6d.) net.

THE OPEN COURT PUBLISHING CO.,

CHICAGO: 324 Dearborn Street.

LARGEST CAMERA IN THE WORLD



WAS CONSTRUCTED ESPECIALLY BY ORDER OF THE

CHICAGO & ALTON

RAILWAY, TO PHOTOGRAPH THE ALTON LIMITED.
SEND A 2c. STAMP TO GEO. J. CHARLTON, G. P. A., C. & A. RAILWAY, CHICAGO, ILL., AND RECEIVE AN ILLUSTRATED PAMPHLET WITH FULL ACCOUNT OF THE FIRST EXPOSURE MADE WITH THE EXTRAORDINARY MACHINE.

Harvard University

LAWRENCE SCIENTIFIC SCHOOL

Twelve programmes of study leading to the degree of Bachelor of Science: in Engineering, Mining, Architecture, Landscape Architecture, Chemistry, Geology, Biology, Science for Teachers, and General Science.

For information concerning admission, courses of study, expenses, etc., address J. L. LOVE, Secretary, 16 University Hall, Cambridge, Mass. N. S. SHALER, Dean.

The National Geographic Magazine

An illustrated monthly published for the NATIONAL GEOGRAPHIC SOCIETY. Editorial communications should be addressed to the Managing Editor of the NATIONAL GEOGRAPHIC MAGAZINE, Corcoran Building, Washington, D. C.

25 Cents a Number; $2.50 a Year

McClure, Phillips & Co.
Publishers .. .. .. New York

IN ITS 51st THOUSAND.

Monsieur Beaucaire

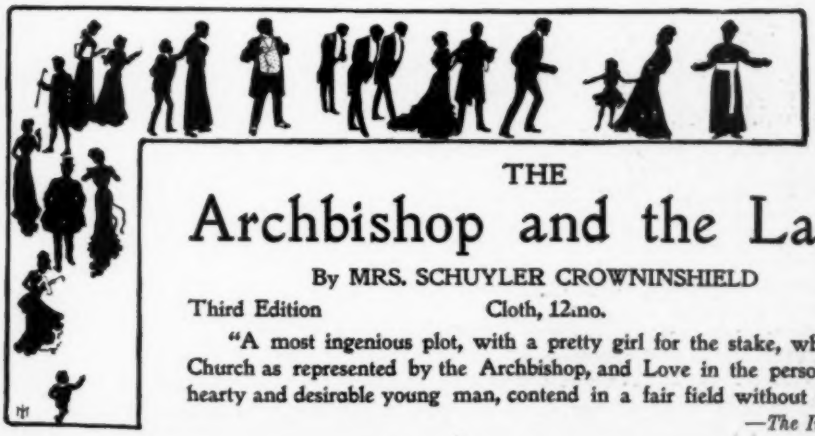
"Since Stevenson laid aside his pen there has not appeared in English speech anything so worthy of the word perfection as Booth Tarkington's 'MONSIEUR BEAUCAIRE.' It is a piece of literature. It is a poem, an idyl, the very flower of romance, and the one exception, in this weary historical array, which seems to have breathed into it the breath of immortality."—*St. Paul Dispatch.*

ILLUSTRATED IN COLORS, $1.25

EVERY BUSINESS WOMAN

and everyone else will like CAROL DARLINGTON, the heroine of THE DARLINGTONS. She is a girl with a head as well as a heart.

APRIL'S SOWING—A Love Story by Gertrude Hall, cloth, 12mo.	$1.50
LOVE—A prettily bound and printed collection of short Love Stories,	.50
THE CIRCULAR STUDY—By Anna Katharine Green, cloth, 12mo.	1.25
THE DAY OF WRATH—By Maurus Jokai, cloth, 12mo.	1.25
AN EAGLE FLIGHT—A Filipino Novel, by Dr. Jose Rizal, cloth, 12mo.	1.25
THE FUGITIVES—By Morley Roberts, cloth, 12mo.	1.00



THE

Archbishop and the Lady

By MRS. SCHUYLER CROWNINSHIELD

Third Edition Cloth, 12mo. $1.50

"A most ingenious plot, with a pretty girl for the stake, while the Church as represented by the Archbishop, and Love in the person of a hearty and desirable young man, contend in a fair field without favor."
—*The Interior.*

McClure, Phillips & Co., New York

WORKS PUBLISHED BY

The Health-Culture Co.

Womanly Beauty of Form and Feature. The Cultivation of Personal Beauty based on Hygiene and Health-Culture, by twenty Physician and Specialists, with 80 illustrations. Edited by Albert Turner, the publisher of "Health-Culture." 12mo, extra cloth, $1.00.

The New Methods in Health and Disease. A guide to the Home Treatment of the Sick, by W. E. Forest, B. S., M. D. Thirteenth Ed. Revised, Enlarged and Illustrated by Albert Turner. $1.00.

Constipation, Its Causes and the Proper Treatment without the Use of Drugs, by W. E. Forest, M. D. In paper, 10c.

Hygienic Cookery, or Health in the Household, by Susanna W. Dodds, M. D., 600 pages, bound in cloth, $2.00

The Diet Question, giving the Reasons Why, by Susanna W. Dodds, M. D. 25c.

The Liver and Kidneys, with a chapter on Malaria. Part I, The Liver and its Functions, Diseases and Treatment. Part II, The Kidneys, their Healthy Action and How to Secure It. Part III, Malarial Fever, Rational Treatment by Hygienic Methods. By Dr. Dodds. 25c.

Cooking for Health, with Health Hints by Rachel Swain, M. D. Oil cloth binding, $1 00.

Human Nature Explained. A New Illustrated Treatise on Human Science for the People, by Prof. N. N. Riddell. Illustrated, 400 pages, extra cloth binding, $1.50.

The Food Value of Meat. Flesh Food Not Essential to Physical, Mental or Vigor. by W. R. C. Latson, M. D., editor of "Health-Culture." Illustrated. Paper, 25c. Cloth, 50c.

Consumption. Hygienic Treatment. In three parts. I. Nature and Causes of the Disease. II. Prevention and Treatment in its Earlier Stages. III. Treatment in More Advanced Stages. By M. L. Holbrook, M. D. 50c.

Health-Culture, a Journal of Practical Hygiene; W. R. C. Latson, M. D., Editor. The best health magazine published, and numbers among its contributors the leading writers on health and hygiene. Felix L. Oswald, M. D, Chas. E. Page, M. D., Prof. Edward B. Warman, Prof. Eustace Miles, Elmer Lee, M. D., Laura M Wright, M D., Henry Albert Rundlett, M. D., Rachel Swain, M D., Thos. W. Organ, M. D, Prof. N. N. Riddell, James Leonard Corning, Sr., and others.
It is our purpose to make "Health-Culture" of the utmost practical value to its readers, teaching the principals of Good Health by Right Living. Nor do we know of a higher mission; for without health, other blessings fade into insignificance.
Terms of Publication: "Health-Culture" is issued monthly at $1.00 a year, 10c. a number. Foreign subscribers $1.36, with postage.

The above may be ordered through any bookseller, or will be sent by mail on receipt of price.
Agents Wanted. Address

THE HEALTH-CULTURE CO.,
503 "P" Fifth Ave., New York.

SENT FREE. To all who mention this advertisement we will send free a sample copy of "Health-Culture," and catalogue of best health books and appliances.

AN UNUSUAL OPPORTUNITY

to visit the country that to-day is attracting the most attention of any in the world.

The Land of the Czars

A strictly limited party, under the guidance of one who has just returned from a trip through Russia, and has made a careful study of its history and civilization, will sail for Russia in June, making a thorough tour of the country, visiting the principal cities, descending the Volga, driving through the Caucasus, the grandest mountain scenery in Europe, and visiting the historic Crimea. Terms moderate. Details on application. Tours to all parts of Europe conducted on a new principle. Address

BUREAU OF UNIVERSITY TRAVEL, Ithaca, N.Y.

A PRACTICAL VIEW OF THE TRUST PROBLEM.

By J. W. JENKS, Ph.D.

Fourth edition, with five charts in color, small. 12mo. Net. $1 00

"The *meatiest*, most practical treatment of them all. . . There is the happy combination of the college man's principles, analysis and plan, with the business man's acquaintance with facts and touch with reality."
—PROF. F. A. FETLER, *Stanford Univ.*

McClure, Phillips & Co.,
141 East 25th Street, New York.

SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE

EDITORIAL COMMITTEE

S. NEWCOMB, Mathematics; R. S. WOODWARD, Mechanics; E. C. PICKERING, Astronomy; T. C. MENDENHALL, Physics; R. H. THURSTON, Engineering; IRA REMSEN, Chemistry; J. LE CONTE, Geology; W. M. DAVIS, Physiography: HENRY F. OSBORN, Paleontology; W. K. BROOKS, C. HART MERRIAM, Zoology, S. H. SCUDDER, Entomology; C. E. BESSEY, N. L. BRITTON, Botany; C. S. MINOT, Embryology, Histology; H. P. BOWDITCH, Physiology; J. S. BILLINGS, Hygiene; J. MCKEEN CATTELL, Psychology, J. W. POWELL, Anthropology.

The past history of SCIENCE is a sufficient guarantee of its future usefulness. Such a JOURNAL is essential to the advance and proper recognition of the scientific work of each country, and in America, where men of science are scattered over a great area, with no single center for personal intercourse, it is peculiarly needful. With the growth of science and scientific institutions in America SCIENCE will occupy an even more important position than at present. It will continue to set a standard to the popular press in its treatment of scientific topics, to secure that general interest in science so essential to its material support, to enlarge the place of science in education and in life, and to demonstrate and increase the unity of science and the common interests of men of science

---

PUBLISHED EVERY FRIDAY

Annual Subscription, $5.00. ***Single Numbers, 15 Cents.***

PUBLISHED BY

THE MACMILLAN COMPANY

66 FIFTH AVENUE, NEW YORK

WEBSTER'S INTERNATIONAL DICTIONARY

WEBSTER'S INTERNATIONAL DICTIONARY

A Ω

NEW EDITION. **25,000** New Words, Phrases, Etc.

Prepared under the direct supervision of W. T. HARRIS, Ph.D., LL.D., United States Commissioner of Education, assisted by a large corps of competent specialists and editors.

New Plates Throughout. Rich Bindings. 2364 Pages. 5000 Illustrations.

Better than Ever for Home, School, and Office.

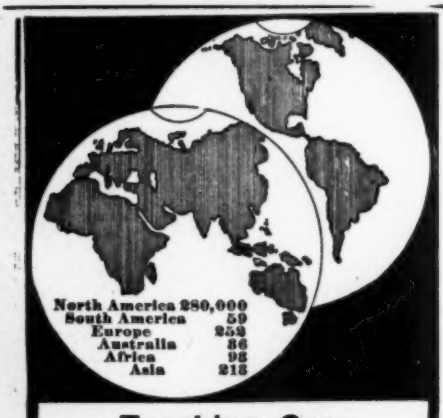
Also **Webster's Collegiate Dictionary** with a valuable Scottish Glossary, etc.

"First class in quality, second class in size." *Nicholas Murray Butler.*

GET THE BEST

Specimen pages, etc., of both books sent on application.

G. & C. MERRIAM CO., Publishers, Springfield, Mass., U. S. A.



Teaching Over 280,000 Students By Mail

THE INTERNATIONAL CORRESPONDENCE SCHOOLS, SCRANTON, PA., is the largest educational institution in the world. It has students in every civilized country. Its enormous growth since beginning in 1891, is the result of its successful method of teaching technical subjects by mail. The International method of helping young people to support themselves while learning to become mechanical or electrical engineers or architects is explained in our latest circular entitled

Salaried Positions for Learners

Mechanical, Electrical, Steam and Civil Engineering; Architecture; Drawing; Chemistry; Telegraphy; Teaching; Stenography; Book-keeping; English Branches. When writing state subject in which interested.

International Correspondence Schools, Box 1168 Scranton, Pa.
Established 1891. Capital $1,500,000.

EUROPE

Easter party to Rome $250. Summer tour for students and others, conducted by University man. 50 days $200. June party conducted by Dr. and Mrs. Draper, 66 Morgan St., Ilion, N. Y. **Write for booklet.**

UNIVERSITY OF WISCONSIN.

COLLEGE OF ENGINEERING.

All the engineering courses, besides a General Course, with liberal electives for persons not expecting to follow engineering as a profession, *in Engineering Science and Practice.* Athletic advantages unexcelled. Fees moderate. "Madison has the most magnificent site of any inland town in America," and it is as healthful as it is beautiful. Address

J. B. JOHNSON, Dean, Madison, Wis.

BOOKS ON... **CHEMISTRY, TECHNOLOGY**
SANITARY SCIENCE
Catalogues Free **MEDICINE & Allied Sciences**

P. BLAKISTON'S SON & CO.
1012 Walnut St., Philadelphia

Bound Volumes of the

Popular Science Monthly

From Vols. 1 to 55 inclusive - Green Cloth, $3.50
Volumes 56, 57, 58 and 59 - Green Cloth, $2.50

McClure, Phillips & Co.,
141 East 25th Street - NEW YORK.

"THE DIAL

SEEMS at present the most unbiassed, good-humored, and sensible organ of American criticism."
—Barret Wendell's "Literary History of America," 1900.

To introduce The Dial to NEW READERS, the publishers will send four consecutive numbers (two months) to any responsible person (not already a subscriber) who will signify a desire for them and enclose 25 cents in stamps; and in addition a copy will be sent FREE of the historic "Twentieth Anniversary Number," issued May 1, 1900, containing an authoritative résumé of literary activity in America for two decades. Address

Semi-monthly; $2 Year. **THE DIAL** FINE ARTS BUILDING CHICAGO : : ILLINOIS

THE POPULAR SCIENCE MONTHLY

Established in 1872 by Messrs. D. Appleton and Company, and Dr. E. L. Youmans

THE POPULAR SCIENCE MONTHLY is published by Messrs. McClure, Phillips and Co., New York, and edited by Prof. J. McKeen Cattell, of Columbia University, with the assistance of Dr. E. L. Thorndike, also of Columbia University.

The fifty-seven volumes of the journal already published have performed an important service for the advancement and diffusion of knowledge. Its issues have each month carried to all parts of the country reliable information in regard to the advances of science, widening and deepening everywhere an intelligent interest in scientific subjects. The journal represented the doctrine of evolution before its tenets were generally accepted; it has done much to diffuse knowledge of physical science and of the applications of science; it has been a factor in the development which has reformed our entire educational system from the kindergarten to the university; its contributors have included many of the world's greatest men of science.

THE POPULAR SCIENCE MONTHLY aims to represent fully and accurately the advance of science; to permit the leading men of science to bring their work before the largest public; to set a standard to the popular press in its treatment of scientific topics; and to secure the general interest in science that is needed for its adequate recognition and support.

A journal with these aims is necessary, both to men of science and to the general public. It brings men of science into contact with those whose sympathy and help they need, while it enables the general public to follow intelligently the progress of science and its contributions to civilization. This double service of THE POPULAR SCIENCE MONTHLY is fully recognized; it has the largest circulation of any scientific journal in the world, and it is conducted with the support of the leading men of science, including in America:

Cleveland Abbe, Professor of Meteorology, United States Weather Bureau.
Cyrus Adler, Librarian, Smithsonian Institution.
Edward Atkinson, Boston.
W. O. Atwater, Professor of Chemistry, Wesleyan University.
J. A. Allen, Curator of Vertebrate Zoölogy, American Museum of Natural History.
L. H. Bailey, Professor of Horticulture, Cornell University.
Marcus Baker, United States Geological Survey.
J. Mark Baldwin, Professor of Psychology, Princeton University.
Lewellys F. Barker, Professor of Anatomy, University of Chicago.

E. E. Barnard, Professor of Astronomy, Yerkes Observatory, University of Chicago.
C. R. Barnes, Professor of Botany, University of Chicago.
Carl Barus, Professor of Physics, Brown University.
Charles E. Bessey, Professor of Botany, University of Nebraska.
J. S. Billings, Director of the Consolidated Libraries, New York City.
Lewis Boss, Director, Dudley Observatory, Albany, N. Y.
H. Carrington Bolton, Washington, D. C.
J. C. Branner, Professor of Geology, Leland Stanford Junior University.
Lewiss Boss, Director, Dudley Observatory, Albany, N. Y.
H. P. Bowditch, Professor of Physiology, Harvard University.
N. L. Britton, Director of the New York Botanical Gardens.
W. K. Brooks, Professor of Zoölogy, Johns Hopkins University.
H. C. Bumpus, Professor of Comparative Anatomy, Brown University.
William H. Burr, Professor of Engineering, Columbia University.
Nicholas Murray Butler, Professor of Philosophy and Education, Columbia Univ.
T. C. Chamberlin, Professor of Geology, University of Chicago.
R. H. Chittenden, Professor of Physiological Chemistry, Yale University.
W. B. Clark, Professor of Geology, Johns Hopkins University.
F. W. Clarke, Chemist, United States Geological Survey.
John E. Clarke, Professor of Mathematics, Yale University.
F. N. Cole, Professor of Mathematics, Columbia University.
George C. Comstock, Director, Washburn Observatory, University of Wisconsin.
J. H. Comstock, Professor of Entomology in Cornell University and in Leland Stanford Junior University.
O. F. Cook, United States Department of Agriculture.
John M. Coulter, Professor of Botany, University of Chicago.
Frederick V. Coville, Division of Botany, U. S. Department of Agriculture.
F. B. Crocker, Professor of Electrical Enginering, Columbia University.
Whitman Cross, U. S. Geological Survey.
Charles W. Dabney, President of the University of Tennessee.
W. H. Dall, United States National Museum, Washington, D. C.
Charles L. Dana, Professor of Nervous Diseases, Cornell Medical School.
E. S. Dana, Professor of Physics, Yale University.
Charles B. Davenport, Assistant Professor of Zoölogy, University of Chicago.
George M. Dawson, Director of the Geological Survey of Canada.
W. M. Davis, Professor of Geology, Harvard University.
Bashford Dean, Adjunct Professor of Zoölogy, Columbia University.
John Dewey, Professor of Philosophy, University of Chicago.
J. S. Diller, United States Geological Survey.
Richard E. Dodge, Teachers' College, Columbia University.
H. H. Donaldson, Professor of Neurology, University of Chicago.
T. M. Drown, President of Lehigh University.
C. E. Dutton, United States Army.
Thomas Dwight, Professor of Anatomy, Harvard University.
M. C. Ernst, Professor of Bacteriology, Harvard University.
W. G. Farlow, Professor of Cryptogamic Botany, Harvard University.
B. E. Fernow, Director of the College of Forestry, Cornell University.
Simon Flexner, Professor of Pathology, University of Pennsylvania.
S. A. Forbes, Professor of Zoölogy, University of Illinois.
C. L. Franklin, Baltimore, Md.
W. S. Franklin, Professor of Physics, Lehigh University.
E. B. Frost, Professor of Astronomy, Yerkes Observatory, University of Chicago.
George S. Fullerton, Professor of Philosophy, University of Pennsylvania.
S. H. Gage, Professor of Histology and Embryology, Cornell University.
B. T. Galloway, Division of Vegetable Physiology and Pathology, United States Department of Agriculture.
W. F. Ganong, Professor of Botany, Smith College.
Wolcott Gibbs, President of the National Academy of Sciences, Professor of Physics (emeritus), Harvard University.
F. H. Giddings, Professor of Sociology, Columbia University.
G. K. Gilbert, United States Geological Survey.
George Lincoln Goodale, Professor of Botany, Harvard University.
A. W. Greely, United States Army.
Arnold Hague, U. S. Geological Survey.
George E. Hale, Director of the Yerkes Observatory, University of Chicago.
Asaph Hall, Professor of Astronomy, Harvard University.
W. Hallock, Adjunct Professor of Physics, Columbia University.
B. D. Halsted, Professor of Botany, Rutgers College.
G. B. Halsted, Professor of Mathematics, University of Texas.
William Harkness, lately Director of the U. S. Naval Observatory.
W. T. Harris, U. S. Commissioner of Education.

Angelo Heilprin, Academy of Natural Sciences, Philadelphia, Pa.
W. H. Howell, Professor of Physiology, Johns Hopkins University.
Robert T. Hill, United States Geological Survey.
C. H. Hitchcock, Professor of Geology, Dartmouth College.
E. S. Holden, lately Director of the Lick Observatory.
W. J. Holland, Chancellor of the Western University of Pennsylvania and Director of the Carnegie Museum, Pittsburg, Pa.
W. H. Holmes, Head Curator of Anthropology, United States National Museum.
J. A. Holmes, State Geologist, North Carolina.
L. O. Howard, Division of Entomology, Department of Agriculture.
James Lewis Howe, Professor of Chemistry, Washington and Lee University.
Alphæus Hyatt, Professor of Biology and Zoölogy, Boston University.
Harold Jacoby, Adjunct Professor of Practical Astronomy, Columbia University.
Joseph Jastrow, Professor of Psychology, University of Wisconsin.
Harry C. Jones, Associate in Physical Chemistry, Johns Hopkins University.
David Starr Jordan, President Leland Stanford Junior University.
Edwin O. Jordan, Assistant Professor of Bacteriology, University of Chicago.
J. F. Kemp, Professor of Geology, Columbia University.
James E. Keler, Director of the Lick Observatory.
C. A. Kofoid, Assistant Professor of Zoölogy, University of Illinois.
J. S. Kingsley, Professor of Zoölogy, Tufts College.
S. P. Langley, Secretary of the Smithsonian Institution.
Joseph Le Conte, Professor of Geology and Natural History, Univ. of California.
Frederic S. Lee, Adjunct Professor of Physiology, Columbia University.
William Libbey, Professor of Physical Geography, Princeton University.
Frank R. Lillie, Assistant Professor of Zoölogy, Chicago University.
William A. Locy, Professor of Zoölogy, Northwestern University.
Jacques Loeb, Professor of Physiology, University of Chicago.
Morris Loeb, Professor of Chemistry, New York University.
F. A. Lucas, Curator of Vertebrate Fossils, United States National Museum.
Graham Lusk, Professor of Physiology, University and Bellevue Hospital Medical College, New York City.
W J McGee, Ethnologist in charge of the Bureau of American Ethnology.
Frank M. McMurry, Professor of Teaching, Columbia University.
Wm. McMurtrie, Chemist, New York City.
D. T. MacDougal, Director of the Laboratories, New York Botanical Gardens.
W. F. Magie, Professor of Physics, Princeton University.
E. L. Mark, Professor of Zoölogy, Harvard University.
C. L. Marlatt, Division of Entomology, United States Department of Agriculture.
O. T. Mason, Curator, Division of Ethnology, United States National Museum.
T. C. Mendenhall, President of the Worcester Polytechnic Institute.
C. Hart Merriam, Biological Survey, U. S. Department of Agriculture.
George P. Merrill, Head Curator of Geology, U. S. National Museum.
Mansfield Merriman, Professor of Engineering, Lehigh University.
C. S. Minot, Professor of Histology and Embryology, Harvard University.
Clarence B. Moore, Philadelphia, Pa.
E. W. Morley, Professor of Chemistry, Adelbert College.
T. H. Morgan, Professor of Biology, Bryn Mawr College.
Edward S. Morse, Peabody Academy of Science, Salem, Mass.
A. J. Moses, Professor of Mineralogy, Columbia University.
Charles E. Munroe, Professor of Chemistry, Columbia University.
Hugo Münsterberg, Professor of Psychology, Harvard University.
S. Newcomb, U. S. N., Professor of Mathematics and Astronomy, Johns Hopkins University.
F. H. Newell, United States Geological Survey.
J. U. Nef, Professor of Chemistry, University of Chicago.
Edw. L. Nichols, Professor of Physics, Cornell University.
H. F. Osborn, Professor of Zoölogy, Columbia University, Curator of Paleontology, American Museum of Natural History, New York.
A. S. Packard, Professor of Zoölogy and Geology, Brown University.
G. T. W. Patrick, Professor of Philosophy, University of Iowa.
B. O. Pierce, Professor of Mathematics and Natural Philosophy, Harvard Univ.
C. S. Pierce, Milford, Pa.
Edward C. Pickering, Director of the Harvard College Observatory.
W. T. Porter, Associate Professor of Physiology, Harvard University.
J. H. Powell, Director of the Bureau of American Ethnology.
Henry S. Pritchett, Superintendent of the United States Coast and Geodetic Survey, President-elect of the Massachusetts Institute of Technology.
T. Mitchell Prudden, Director of the Pathological, Histological and Bacteriological Laboratories, Columbia University.
M. I. Pupin, Adjunct Professor of Mechanics, Columbia University.

F. W. Putnam, Professor of American Archæology and Ethnology, Harvard University; Curator of Anthropology, American Museum of Natural History.
J. K. Rees, Director of the Columbia College Observatory.
Jacob Reighard, Professor of Zoölogy, University of Michigan.
Ira Remsen, Professor of Chemistry, Johns Hopkins University.
Edward Renouf, Collegiate Professor of Chemistry, Johns Hopkins University.
T. W. Richards, Assistant Professor of Chemistry, Harvard University.
William Z. Ripley, Assistant Professor of Sociology and Economics, Massachusetts Institute of Technology.
Ogden N. Rood, Professor of Physics, Columbia University.
Josiah Royce, Professor of Philosophy, Harvard University.
Israel C. Russell, Professor of Geology, University of Michigan.
James E. Russell, Professor of the History of Education, Teachers' College, Columbia University and Dean of the College.
Rollin D. Salisbury, Professor of Geographical Geology, University of Chicago.
Charles Schuchert, Division of Stratigraphy and Paleontology, United States National Museum.
E. A. De Schweinitz, Chief of the Bio-Chemic Division, Dept. of Agriculture.
Samuel H. Scudder, Cambridge, Mass.
William T. Sedgwick, Professor of Biology, Massachusettts Institute of Tech.
N. S. Shaler, Professor of Geology, Harvard University.
Edgar F. Smith, Professor of Chemistry, University of Pennsylvania.
Theobald Smith, Professor of Comparative Pathology, Harvard University.
F. Starr, Assistant Professor of Anthropology, University of Chicago.
M. Allen Starr, Professor of Psychiatry, Columbia University.
W. Le Conte Stevens, Professor of Physics, Washington and Lee University.
George M. Sternberg, U. S. A., Surgeon-General.
J. J. Stevenson, Professor of Geology, New York University.
Charles Wardell Stiles, Bureau of Animal Industry, Washington, D. C.
H. N. Stokes, United States Geological Survey.
F. H. Storer, Professor of Agricultural Chemistry, Harvard University.
George F. Swan, Professor of Civil Engineering, Mass. Institute of Technology.
Elihu Thomson, Lynn, Mass.
R. H. Thurston, Director of Sibley College for Mechanical Engineering, Cornell University.
E. B. Titchener, Professor of Psychology, Cornell University.
William Trelease, Director of the Missouri Botanical Garden.
John Trowbridge, Professor of Physics, Harvard University.
L. M. Underwood, Professor of Botany, Columbia University.
F. P. Venable, President of the University of North Carolina.
Charles D. Walcott, Director of the U. S. Geological Survey.
Henry B. Ward, Professor of Zoölogy, University of Nebraska.
Andrew D. White, United States Ambassador to Germany.
Burt G. Wilder, Professor of Physiology and Neurology, Cornell University.
H. W. Wiley, Division of Chemistry, United States Department of Agriculture.
Bailey Willis, United States Geological Survey.
E. B. Wilson, Professor of Zoölogy, Columbia University.
R. W. Wood, Professor of Physics, University of Wisconsin.
R. S. Woodward, Professor of Mechanics and Mathematical Physics, Columbia University.
Arthur W. Wright, Professor of Experimental Physics, Yale University.
Carroll D. Wright, Commissioner of Labor, Labor Department.
W. J. Youmans, lately Editor of THE POPULAR SCIENCE MONTHLY.
C. A. Young, Director, Halsted Observatory, Princeton University.

The annual subscription to the POPULAR SCIENCE MONTHLY is $3.00. The numbers are for sale on all news-stands for 25 cents

The Monthly is published on the 24th of every month by

McCLURE, PHILLIPS AND CO

141 EAST 25th STREET, NEW YORK

ELECTRICAL EDUCATION

"ELECTRIC LIGHT HOME."

Teaches Electricity Complete and Illustrated. Price, 10c. Postpaid.

A little book, but it contains explicit instructions which TEACH YOU HOW to make a Chemical Battery Installation at a very little outlay, so that you can have BRILLIANT electric light in your residences for all purposes WITHOUT MACHINERY.

The book is thorough, in few words, and illustrated with practical diagrams, formulas, etc, being written understandingly for everybody.

IT TEACHES ELECTRICITY IN PLAIN LANGUAGE.

A New York minister states that he lectured on electricity through knowledge obtained from this book.

A reader (a U. S. Army Engineer) writes that this book TAUGHT HIM more about ELECTRICITY than his entire library of electrical books.

Testimonials of the highest character from thousands of men and women in all capacities of life. The writer of "Electric Light Home" has received SEVEN AWARDS for his many inventions.

I supply Strong Electric Motors for $1 and up. Money refunded if not satisfactory. Electric Lamps, 1 to 6 candle power, 40 cents each. :: :: :: :: :: :: ::

BUSINESS ESTABLISHED 1886

ADDRESS .... **JAS. H. MASON (Inventor),**

Dept. P. S. **Telephone, 4036 John.** **150 Nassau St., N. Y.**

THE POWERS THAT PREY

CRIMINAL AND POLICE STORIES

BY

JOSIAH FLYNT

and

FRANCIS WALTON

CLOTH, 12mo. $1.25

"A book of unusual interest . . . first hand studies, in short story form, of the criminal regarded, not as a case, but as a man . . . a book before the intense actuality of which mere literary work seems somehow insignificant."—

New York Evening Post.

AT ALL BOOKSTORES

MICROSCOPES

AT DUTY FREE PRICES.

We are offering the

New Continental Microscope

made by R. & J. BECK, of London, at the lowest rates ever offered to Educational Institutions. Thus saving thirty-five to forty per cent. from American prices.

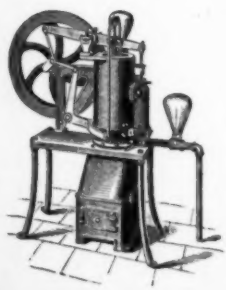
SPECIAL PRICES ON BOTANICAL SUPPLIES.

The new pocket Aplanat, $1.00 to $1.50 less thirty-three-and-a-third per cent. Botanical collecting cases, 75c. to $1.50. Plant Presses, 60c. to $1.50. Botanical mounting papers and entomological pins at special rates.

SEND FOR CATALOGUE AND SPECIAL PRICES.

Williams, Brown & Earle

DEPT. N. **Philadelphia, Pa.**



Water Every Day in the Year

Whether the wind blows or not, is furnished by the Rider and Ericsson Hot Air Pumps, nearly 20,000 of which are in daily use. Especially valuable for country residences and other places where a constant supply of water is necessary, and where absolute safety is also a consideration. A record of 25 years is reassuring. Apply to nearest store for catalogue "B. 4."

RIDER-ERICSSON ENGINE CO.

22 Cortlandt St., New York
239 Franklin St., Boston
22A Pitt St., Sydney, N. S. W.
Teniente-Rey 71, Havana
86 Lake St., Chicago
40 N. 7th St., Philadelphia
692 Craig St., Montreal, P. Q.
Merchant and Alakea Sts., Honolulu

Lackawanna Railroad
The general completeness of arrangement makes it an ideal route for ladies travelling alone from New York to Buffalo. I am an exceptional good traveller and appreciate the comfort of the Lackawanna.
Sincerely Stella Allen.
The Lackawanna Railroad. New York
Gentlemen,
For ease and comfort to the traveller commend me to the Lackawanna System. The freedom from dust insures fresh linen & one's travelling clothes, and

MAGNIFICENT DAILY SERVICE BETWEEN

NEW YORK and BUFFALO
NEW YORK and CHICAGO
NEW YORK and ST. LOUIS

Tickets and reservations at 429 Broadway; 289 Main Street, Buffalo; 108 Adams Street, Chicago; Eighth and Olive Streets, St. Louis.

The Lackawanna Railroad presents unexcelled locations and opportunities for industries and manufactories.

General Offices: 26 Exchange Place, New York City.

AMERICAN BANK NOTE CO. N.Y.

NEVER HAD AN EQUAL.

Competent judges say that the Pan-American Exposition will be superior to anything of its kind ever seen on this continent, and it is within 12 hours' ride of over forty million people. How can it fail to be a success, when you consider that it is reached from all directions by the

NEW YORK CENTRAL LINES,

which comprise the New York Central, Boston & Albany, Michigan Central, Lake Shore, Big Four, Pittsburg & Lake Erie and Lake Erie & Western Railways.

For a copy of the New York Central's Pan-American Exposition Folder "Four-Track Series" No. 15, send a postage stamp to George H Daniels, General Passenger Agent New York Central Railroad, Grand Central Station, New York.

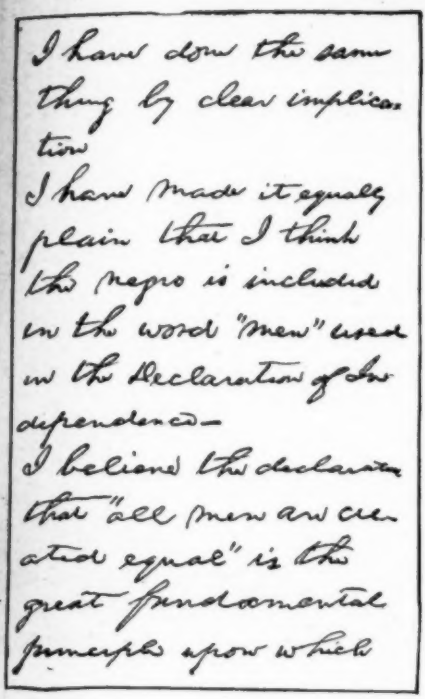
Thousands Say

does beautifully clean cut work, and is perfectly satisfactory. If you want your correspondence to be first class, use

The *New Century* TYPEWRITER.

Write for our new booklet **"Why?"**

AMERICAN WRITING MACHINE COMPANY,
302 BROADWAY, NEW YORK.


I have done the same thing by clear implication
I have made it equally plain that I think the negro is included in the word "men" used in the Declaration of Independence—
I believe the declaration that "all men are created equal" is the great fundamental principle upon which

Abraham Lincoln:

His Book.

A fac-simile reproduction of the only book Lincoln ever had a hand in making. The accompanying autograph reproduction is a reduced fac-simile of one of the pages.

Leather. 16mo. $1.00 net

By IDA M. TARBELL.

The Life of Lincoln

In two volumes.

100 Illustrations. Cloth. **$5.00**

Napoleon:

With a Sketch of Josephine.

A new, revised and enlarged edition.

Richly illustrated. Cloth, 12mo. **$2.50**

What We Know About Genesis.

By DR. ELWOOD WORCESTER.

Illustrated. Cloth, 12mo. **$2.00**

A thorough and reverential treatment of early biblical knowledge in the light of modern science.

Four Books of Timely Interest.

The Philippines:

The War and the People

Being a record of Personal Observations and Experiences by

ALBERT G. ROBINSON.

Cloth, large 12mo. **$2.00**

An American Engineer in China

By WILLIAM BARCLAY PARSONS.

Cloth, 12mo. **$1.50**

"We doubt if any other book on China will be quite so interesting to the practical American mind as this."—*Book Lovers' Library.*

The Awakening of the East

By PIERRE LEROY-BEAULIEU.

With an introduction by Henry Norman.

Cloth, 12mo. **$1.50**

"The best book on China, Siberia and Japan," says the *New York Evening Post.*

The Great Boer War

By A. CONAN DOYLE.

Cloth, 12mo. **$1.50**

An account of the war in South Africa up to and including the annexation of the Boer Republics by England.

McClure, Phillips & Co., New York

COPYRIGHT 1901 BY THE PROCTER & GAMBLE CO CINCINNATI

THE increase of culture and intelligence brings a demand for more highly refined and better articles of home use and consumption. Ivory Soap, by reason of its purity, lack of objectionable perfume and color, the freedom with which it can be used without injury, and its perfect fitness for the toilet and bath, makes it the favorite soap with people who choose carefully.

The Trust Problem

By J. W. JENKS, Ph.D.

"The most instructive contribution that has thus far been made to the discussions of the trust problem. It is singularly free from dogmatism and apriorism, and every page is informed with a strong economic philosophy."—PROF. MILLER in the JOURNAL OF POLITICAL ECONOMY.

Third Edition. Cloth, $1.00 net.

The Gavel and the Mace

By HON. FRANK W. HACKETT

"Mr. Hackett's book not only bubbles over with humor, but it has more than humor; it is pervaded with good sense and a good spirit, and it contains an excellent compendium of parliamentary law."—JOHN D. LONG, Secretary of the Navy.

Cloth, 12mo. $1.25

The Doctrines of Grace

By REV. DR. JOHN WATSON.

"A warmth of feeling, quickness of intellect and common sense which should make them acceptable not only within but beyond the circle of assent to the doctrines involved in them."—THE DIAL, Chicago. Cloth, 12mo. $1.50

A Captive of War

By SOLON HYDE.

"In all others of the stories we have read during this season we have found nothing more vivid than this experience of the greatest war of the century."—BUFFALO COMMERCIAL. Cloth, 12mo. $1.00

DWIGHT L. MOODY: Impressions and Facts.

By HENRY DRUMMOND.

Introduction by George Adam Smith. Cloth, 12mo. $1.00

ULYSSES S. GRANT: His Life and Character.

By HAMLIN GARLAND.

With 32 Illustrations. Cloth, 8vo. $2.50

THE SCHOOL AND SOCIETY. Third Edition.

By DR. JOHN DEWEY.

Illustrated. Cloth, 12mo. $1.00

ENCYCLOPAEDIA OF ETIQUETTE

WHAT TO DO
WHAT TO SAY
WHAT TO WRITE
WHAT TO WEAR

A BOOK OF MANNERS FOR EVERYDAY USE

Illustrated. Cloth, 12mo. $2.00

The American Salad Book . .

Over 300 useful recipes. The most useful, complete and original collection ever brought together.

Cloth, 12mo. $1.00

// McClure, Phillips & Co., New York //

THE
GRAND UNION
HOTEL
Directly opposite the
Grand Central Depot,
42d Street and Park Avenue,
NEW YORK.

Rates, $1 a day and upwards

NEW MODELS
FOR 1901
DENSMORES No. 4 AND

A Long Lead Taken in the Number of Sales Accomplished by Typewriting Machines.

Nice Booklet Gratis.

Densmore Typewriter Co. 309 Broadway New York

CLYDE LINE

WM. P. CLYDE & CO. GENERAL AGENTS.

THEO. G. EGER. GENERAL MANAGER.

To FLORIDA